# FEDERAL AVIATION REGULATIONS

**DEPARTMENT OF TRANSPORTATION**
**FEDERAL AVIATION ADMINISTRATION—WASHINGTON, DC**

CHANGE 6 | EFFECTIVE: JUNE 10, 1996
AUGUST 8, 1996

## Part 29—Airworthiness Standards: Transport Category Rotorcraft

This change incorporates two amendments:

Amendment 29–39, Airworthiness Standards; Transport Category Rotorcraft Performance, adopted May 2 and effective June 10, 1996, and

Amendment 29–40, Rotorcraft Regulatory Changes Based on European Joint Aviation Requirements, adopted May 2 and effective August 8, 1996. Sections 29.547, 29.610, 29.629, 29.631, 29.917, 29.923, 29.1305, 29.1309, 29.1351, 29.1587, and Appendix B, VIII(b) are affected by this amendment.

Bold brackets enclose the most recently changed or added material. The amendment number and effective date of new material appear in bold brackets at the end of each affected section.

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# Part 29—Airworthiness Standards: Transport Category Rotorcraft

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## Amendment 29–39

## Airworthiness Standards; Transport Category Rotorcraft Performance

**Adopted: May 2, 1996** **Effective: June 10, 1996**

**(Published in 61 FR 21894, May 10, 1996)**
**(Corrected in 61 FR 29931, June 13, 1996)**

**SUMMARY:** This rule adopts new and revised airworthiness standards for the performance of transport category rotorcraft. The changes define more clearly the factors for determining takeoff, climb, and landing performance requirements. These changes provide an improved level of safety associated with recent technological advances in the design of turboshaft engines and rotorcraft.

**FOR FURTHER INFORMATION CONTACT:** T.E. Archer, Policy and Procedures Group (ASW–110), Rotorcraft Standards Staff, Aircraft Certification Service, Federal Aviation Administration, Fort Worth, TX 76193–0110; telephone (817) 222–5126.

**SUPPLEMENTARY INFORMATION:**

### Background

This final rule is based on a Notice of Proposed Rulemaking (NPRM) (Notice 90–1), issued January 2, 1990 (55 FR 698, January 8, 1990). The NPRM was preceded by an Advance Notice of Proposed Rulemaking (ANPRM) (Notice 85–19) issued October 9, 1985 (50 FR 42126, October 17, 1985), and by a public meeting on April 30, 1986 (51 FR 4504, February 5, 1986), in Fort Worth, Texas. A transcript of that meeting is contained in the docket for this rulemaking. Supplemental Notice of Proposed Rulemaking (SNPRM) (Notice 90–1A), issued June 15, 1994 (59 FR 33598, June 29, 1994), modified Notice 90–1 by including a minimum descent height of 15 feet.

Amendment 29–21 (48 FR 4373, January 26, 1983) revised the transport category rotorcraft airworthiness requirements to provide for an increased level of safety in several areas, including performance. Subsequently, a Federal Aviation Administration (FAA) program to develop guidance material (Advisory Circulars 27–1 and 29–2A) for certification of rotorcraft in accordance with the requirements of Title 14 of the Code of Federal Regulations (Title 14) part 29 (part 29) revealed a need for some additions to and clarification of the provisions of Amendment 29–21. Those additions and clarification are included in this amendment.

Amendment 29–21 modified the applicability limits of Categories A and B of Transport Category Rotorcraft. Category A rotorcraft must meet a higher level of safety, including the requirement to have multiple engines, and be able to continue safe flight after an engine failure. Category B rotorcraft may be either single or multiengine, but the changes adopted in Amendment 29–21 limited this category further to a maximum capacity of nine passengers and 20,000 pounds gross weight. No changes are made to those limits in this amendment.

A significant element of Notice 90–1 was a proposed minimum climb gradient for the Category A takeoff path. This standard was proposed to standardize the climb gradient for helicopters regardless of their airspeeds and to facilitate heliport planning. The present standard requires a minimum rate of climb for the takeoff path; however, recently certificated rotorcraft, as well as most rotorcraft currently under development, produce maximum rates of climb at higher airspeeds than the previous generation of rotorcraft. For a specific rate of climb, the climb gradient decreases as climb airspeed increases. This results in a shallower climb gradient for modern, high-speed rotorcraft than for older, slow-speed rotorcraft. Notice 90–1 proposed a minimum climb gradient based on the present rate-of-climb requirement and the lower airspeed of older rotorcraft. At the time Notice 90–1 was issued, FAA analysis suggested that this change would have involved an acceptably small weight (payload) penalty. However, more precise data supplied by the commenters in response to the notice indicate there would be a payload penalty of 450 pounds or greater for a current 10,000-pound class helicopter. This could represent as much as 20 to 25 percent of the passenger payload, which one commenter characterized as totally unacceptable. Upon reconsideration, the FAA agrees that the proposal would have a significantly more burdensome effect and would not be cost beneficial, and as noted in the following discussion, the proposal for requiring minimum climb gradient is not adopted in this rule.

All interested persons have been given an opportunity to participate in the making of these amendments, and due consideration has been given to all comments received. Except for the change described above and for the nonsubstantive, editorial, and clarifying changes as discussed herein, the proposals have been adopted as proposed.

**Discussion of Comments**

Five commenters each responded to Notices 85–19 and 90–1. These commenters represent worldwide manufacturers, operators, and airworthiness authorities. The commenters' recommendations and the suggested changes are summarized in the following discussions. Four commenters responded to Notice 90–1A and all agreed with that proposal.

*14 CFR 29.1 Applicability*

Notice 90–1 proposed to change the reference in paragraph (e) from §§ 29.79 to 29.87, which is redesignation of the section number for the height-velocity envelope. There were no comments; therefore, the proposal is adopted.

*New 14 CFR 29.49 Performance at Minimum Operating Speed (Old § 29.73)*

Notice 90–1 proposed to redesignate § 29.73 as § 29.49 to relocate the requirements for helicopter hover performance. For transport category helicopters, hover performance is analogous to the stall speed for transport category airplanes and provides the basis for all other performance requirements. Therefore, by placing the requirements for hovering performance first, the other requirements more logically follow.

One commenter proposes a requirement for one-engine-inoperative (OEI) hover performance both in and out-of-ground effect (OGE). This comment, also made in response to the ANPRM, is beyond the scope of this rule as proposed in the notice.

This commenter also recommends that OGE controllability (in 17-knot winds from any direction) should also be required. The FAA disagrees. Past FAA policy has permitted OGE performance to be presented in zero wind if a minimum of yaw control remains (i.e., must be able to generate a positive yaw rate) or to be demonstrated with some wind condition if the demonstrated conditions are clearly identified in the Rotorcraft Flight Manual (RFM). The validity of this policy has been borne out by good service experience; therefore, the 17-knot criteria are not considered necessary in determining OGE controllability. Therefore, the FAA considers the calm-wind OGE hover performance data with no related controllability limit are the minimum data that should be provided, and the amendment is adopted as proposed. The requirement to provide performance information about OGE hover and the maximum safe wind for the data presented is clarified in the new § 29.1587(a)(6) and revised § 29.1587(b)(8).

*14 CFR 29.51 Takeoff Data: General*

Notice 90–1 proposed to change the sections referenced in the introductory text of paragraph (a) to correspond to the applicable sections numbered in accordance with these new amendments. No comments were received; therefore, the proposal is adopted as proposed.

*14 CFR 29.53 Takeoff: Category A*

This proposal would separate, in the text, the Category A takeoff requirement from the definition of a decision point. No comments were received; therefore, the proposal is adopted as proposed.

*New 14 CFR 29.55 Takeoff Decision Point: Category A*

Notice 90–1 proposed to add this new section to redefine the takeoff critical decision point (CDP) previously contained in § 29.53; it further proposed to remove the requirement to identify the CDP by height and airspeed, since height alone or other factors may be more appropriate. A commenter suggests that the section title and other references to "critical decision point" be changed to "takeoff decision point (TDP)." The commenter notes that TDP is compatible with the term "landing decision point (LDP)" already in other regulatory parts. The FAA agrees; accordingly, "critical decision point" is changed to "takeoff decision point."

Additionally, a commenter to § 29.59 states that engine failure and the TDP do not occur at the same time because of necessary pilot-recognition time. The FAA agrees that a time interval for pilot recognition of the engine failure must be included when establishing the TDP. Calculating a pilot-recognition time interval when determining the TDP is a natural part of the TDP-determining process. Current industry practice already adequately considers this pilot-recognition time interval in determining the TDP. Therefore, to explicitly state this requirement in the regulations imposes no additional economic burden on manufacturers. Also, to harmonize Title 14 and the Joint Aviation Requirements (JAR's), the certification requirements for the Joint Aviation Authorities (JAA) of Europe, an explicit adoption of the pilot-recognition time interval is necessary. Therefore, since a pilot-recognition time interval is currently being used by manufacturers, and the FAA and the manufacturers are interested in harmonizing Title 14 and the JAR's, a new paragraph (c) has been added to § 29.55 to require that a pilot-recognition time interval be included in the TDP determination.

This section is adopted with changes as discussed.

*14 CFR 29.59 Takeoff Path: Category A*

Notice 90–1 proposed to move the rejected takeoff requirements to a new § 29.62 and more clearly define the takeoff path from the start of the takeoff to completion at 1,000 feet above the takeoff surface. It also proposed the new phrase "critical decision point," now changed to "takeoff decision point" as explained in new § 29.55. The most significant proposed change was to establish minimum climb gradients along the takeoff path. Present requirements specify only a rate of climb. The use of gradients would have assisted heliport designers and provided additional safe ground clearance. The FAA estimated that inclusion of these gradients would introduce only a slight performance penalty. However, as discussed earlier, more precise data submitted by commenters indicate that adopting these gradients would result in an unanticipated decrease in the payload of a 10,000-pound class rotorcraft. Therefore, present rate-of-climb requirements are retained; the proposed minimum climb gradient is not adopted; and the remaining paragraphs of § 29.59 are renumbered accordingly.

One commenter proposes that a new section be introduced to require information on the takeoff path acceleration segment distance when accelerating from $V_{TOSS}$ to $V_y$ and that § 29.1587 also be amended to require these data. The commenter's proposal is beyond the scope of Notice 90–1; therefore, the proposal is not included in the amendment as adopted but may be appropriate for future rulemaking.

Another commenter disagrees that engine failure and CDP (now TDP) occur at the same time. The FAA agrees as discussed previously under § 29.55. Accordingly, the proposed § 29.59(a)(2) has been reworded by changing critical decision point to engine failure point; and by adding the phrase, ". . . continue to the TDP, and then . . ." to paragraph (a)(3). These additions clarify that consideration of the time interval between engine failure and the pilot's recognition of the failure is necessary in establishing TDP.

Notice 90–1, with respect to loss of altitude after engine failure, proposed no minimum height during descent to attain $V_{TOSS}$ except that touchdown should not occur. Also, Notice 90–1 proposed that a minimum ground clearance be determined during certification and the data included in the RFM. Several commenters objected to the proposal and stated that a minimum ground clearance value should be specified in the rule. Wide support was expressed by European authorities, manufacturers, and operators to limit the descent to not less than 15 feet above the takeoff surface. Also, this minimum height was reflected in the European JAA, Notice of Proposed Amendment (NPA) 29–2, Preliminary Issue 1. However, since Notice 90–1 proposed to eliminate the existing 35-foot minimum height of part 29, requiring a new minimum height of a specified value in excess of that proposed was more stringent than that proposed in Notice 90–1. Therefore, the FAA issued Notice 90–1A to include a minimum descent height of 15 feet and all commenters agreed. Hence, the minimum descent height of 15 feet is adopted as proposed by Notice 90–1A. However, the paragraph is shown as (e) rather than (g) as proposed by Notice 90–1A due to renumbering as discussed previously.

*New 14 CFR 29.60 Elevated Heliport Takeoff Path: Category A*

Notice 90–1 proposed to add this section to introduce the requirements for pinnacle takeoff path, Category A. However, two commenters suggest using the term "elevated" rather than "pinnacle" since "elevated" is a more common term. The FAA agrees, and the word "pinnacle" has been replaced with "elevated heliport" wherever used. Several commenters also recommend that the requirement for takeoff climb gradients be deleted from this section. Therefore, as in the ground-level takeoff path, the climb gradients proposed for this section have also been removed because data submitted by commenters indicate that adopting these gradients would result in an unanticipated decrease in payload.

However, the FAA notes that the proposal for this section was not clear in Notice 90–1. The section, as proposed, would require a continuous maneuver from the start of the takeoff unit reaching 1,000 feet above the takeoff surface with two specific rate-of-climb requirements at 200 and 1,000 feet above the takeoff surface. A continuous climb was never intended by the FAA. For example, if the descent below the takeoff surface is 200 feet, using a continuous climb standard would require a total initial climb of 400 feet to regain a point 200 feet above the takeoff surface. Therefore, climbing at a rate of 100 feet per minute would take 4 minutes to regain a point 200 feet above the takeoff surface while the current One Engine Inoperative (OEI) standards only require that 2½ minutes of emergency power be available. Hence, the time for this descent-climb would not be compatible with the time-limited OEI power level that is permitted. Therefore, this paragraph has been clarified to indicate that the distances to be measured will be the vertical magnitude of any descent below the takeoff surface and the horizontal distance from the start of the takeoff to the point where a positive rate of climb is established at an airspeed of at least $V_{TOSS}$. This will be considered to be the end of the takeoff distance. (See § 29.61.) From the end of the takeoff distance, climb data will be used for the remainder of takeoff path planning. The rate-of-climb requirements at 200 and 1,000 feet above the takeoff surface will remain the same but will be clearly identified as separate requirements and not a part of a continued takeoff maneuver. Climb gradients were also included in the proposal but, as previously discussed, are not adopted. This section is adopted with changes as discussed.

*New 14 CFR 29.61 Takeoff Distance: Category A*

Notice 90–1 proposed to add a new section to define more clearly the parameters to be used in determining takeoff distance. No comments were received on this proposal. However, in view of the previous discussion of elevated heliports and the changes to § 29.60, a second paragraph is added to more clearly define takeoff distances. Also, as discussed for the new § 29.59, a requirement for considering the pilot recognition interval following engine failure is recognized in the new § 29.61. The addition of § 29.61(b) states explicitly that the takeoff distance for elevated heliports is defined the same as that for nonelevated heliports except that there is no requirement that the rotorcraft remain at least 35 feet above the takeoff surface. This provision harmonizes Title 14 and the JAR. Section 29.61(b) relieves applicants from the requirement to attain and maintain at least 35 feet of altitude when determining the takeoff distance from an elevated heliport. Thus, the takeoff distance will be shorter for rotorcraft that take off from an elevated heliport. Thus, the takeoff distance will be shorter for rotorcraft that take off from an elevated heliport that the distance needed to reach 35 feet above the takeoff surface as required by § 29.61(a) for rotorcraft that take off from a nonelevated heliport. This reduction in takeoff distance will result from an exchange of the inherent altitude of the elevated heliport for airspeed and subsequently rate of climb. The FAA has determined that this relieving provision will neither increase the economic burden on any applicant nor increase the scope of this rule. Therefore, the proposal is adopted with the noted changes.

*New 14 CFR 29.62 Rejected Takeoff: Category A*

Notice 90–1 proposed to separate the text of the rejected takeoff criteria from the takeoff path section and impose the restriction for the use of only primary controls while airborne. No comments were received; therefore, the proposal is adopted with the change of CDP to TDP, the change of ''takeoff decision'' to ''engine failure,'' and the addition of ''the rotorcraft continuing to takeoff decision point,'' as explained in the discussion of new § 29.55.

*New 14 CFR 29.64 Climb: General*

This new section relocates and clarifies the general climb requirements. No comments were received; therefore, the proposal is adopted without change.

*14 CFR 29.65 Climb: All Engines Operating*

Notice 90–1 proposed to add a general requirement to determine Category a rotorcraft climb performance. Currently Category A rotorcraft climb performance is required only when $V_{NE}$ (never-exceed speed) is less than best climb speed ($V_Y$) at sea level. No comments were received; therefore, the proposal is adopted without change.

*14 CFR 29.67 Climb: One-engine-Inoperative*

Notice 90–1 proposed to include the takeoff climb gradients as a part of the general climb requirement, as well as the OEI climb requirements to be met at 200 and 1,000 feet above the takeoff surface.

Commenters recommend that the climb gradient requirements be removed. The FAA agrees because data submitted by commenters indicate that adopting these gradients would result in an unanticipated decrease in payload. Therefore, the proposed climb gradient requirements are not adopted. However, the rate of climb requirements are adopted as proposed. Also, various clarifying word changes have been made including adding the words ''climb following'' before ''takeoff'' in paragraph (a)(2)(ii) to clarify that the unfavorable center of gravity applies to the climb following takeoff. The proposal is adopted with the noted changes.

*14 CFR 29.75 Landing: General*

Notice 90–1 proposed to revise the general landing requirements to separate specific requirements and to provide references to those specific landing requirement sections. No comments were received; therefore, the proposal is adopted without change.

*14 CFR 29.77 Landing Decision Point*

Notice 90–1 proposed to add the new requirement for designation of a landing decision point (LDP), which has been an industry practice although not required in all recent Category A certifications. No comments were received; therefore, the proposal is adopted without change except for clarifying that, in accordance with the discussion for § 29.55, pilot recognition time must be considered.

*14 CFR 29.79 Landing: Category A*

Notice 90–1 proposed to establish the Category A landing requirements as a separate section with only minor revision from the present requirements. One commenter discusses studies and computer predictions for approaches and landings at elevated heliports but does not propose any changes. Since no changes were recommended, and the FAA does not see a need for any changes based on the commenters' discussion, the proposal is adopted without change.

*New 14 CFR 29.81 Landing Distance: Category A*

Notice 90–1 proposed a new section to require landing distances to be determined from specific heights. One commenter suggests that the proposed flight profile between LDP and touchdown using an elevated heliport is unduly restrictive. This comment was based on the commenter's concern that the proposal would require consideration of a 25-foot high screen at the approach edge of the elevated heliport. The FAA notes that this is not the intent of this section. The proposed horizontal landing distance determined from a point 25 feet higher than the elevated heliport need not be contained within the heliport landing surface. ''Pinnacle'' has been changed to ''elevated heliport'' in accordance with previous discussions. Therefore, the proposal is adopted with the change as noted.

*New 14 CFR 29.83 Landing: Category B*

Notice 90–1 proposed a new § 29.83 that included moving the Category B landing requirement presently in § 29.75(c) into this new section and required landing distances to be determined power-on rather than power-off. One commenter suggests deleting the requirement to avoid the unsafe area of the height-velocity (HV) envelope since Category B rotorcraft with nine or fewer passengers and less than 20,000 pounds do not have the HV envelope as a limitation and may transit the unsafe area of the HV envelope during landing. The FAA disagrees. While the commenter is correct about the HV envelope not being a limitation for Category B rotorcraft with nine or fewer passengers, the FAA cannot agree with presenting data that include normal operations within the unsafe area of the HV envelope. Certain operations (e.g., external loads and hoist work) are not necessarily limited by the type certification HV envelope; however, the operator still should be aware that the operations do not involve normal procedures, and the operator should evaluate the risk in accordance with the applicable regulations (e.g., part 133). Therefore, the proposal is adopted without change.

*New 14 CFR 29.85 Balked Landing: Category A (Old § 29.77)*

Notice 90–1 proposed to redesignate present § 29.77 as a new § 29.85, to clarify the relationship between the landing decision point and balked landing, and to remove the prohibition against descending below 35 feet above the landing surface. The proposal only specified that the rotorcraft ''not touch down'' during descent. One commenter proposes that some minimum height be required. As previously discussed under § 29.59, the FAA agrees; however, Notice 90–1 proposed to allow the rotorcraft to descend below the current 35-foot height as long as it does not touch down. Therefore, the FAA issued Notice 90–1A to include the 15-foot minimum descent height. Three commenters to Notice 90–1A fully agreed with the proposed changes. One commenter agreed provided the working for § 29.85(c) read identically to the wording of Notice 90–1. However, it was necessary to amend the wording in proposed paragraph (c) to add the minimum descent height restriction requirements. Otherwise, the wording is identical. Also, as previously discussed the term ''elevated'' will be used rather than ''pinnacle.'' Therefore, the proposal is adopted by adding the 15-foot minimum descent height and the amended wording to paragraph (c) and by adding the phrase ''failed and failure recognized'' to paragraph (b) to specify that the time interval for pilot recognition of engine failure must be considered as discussed in § 29.55.

*New 14 CFR 29.87 Height-velocity Envelope (Old § 29.79)*

Notice 90–1 proposed to redesignate § 29.79 as a new § 29.87 and to revise the engine power conditions to be used. No comments were received; therefore, the proposal is adopted with only editorial changes.

*14 CFR 29.1323 Airspeed Indicating System*

Notice 90–1 proposed to change the term ''height-speed'' to ''height-velocity'' to agree with other changes in the proposal. No comments were received; therefore, the proposal is adopted without change.

*14 CFR 29.1587 Performance Information*

Notice 90–1 proposed to change this section to conform to other changes in the proposal. One commenter suggests requiring, as performance information, the steady gradient of climb for each weight, altitude, and temperature for which takeoff data are scheduled for the two conditions between the end of the takeoff and at 1,000 feet above the takeoff surface. The FAA does not agree. This would require a significant increase in the number of flight tests for compilation of data and for FAA verification of this data, with resulting significant adverse economic impact and no perceived safety benefits. As discussed with respect to the new § 29.49, the requirement to provide OGE performance data, including the maximum safe wind for the data presented, is added to the Category A requirements in § 29.1587(a)(6). Also, § 29.1587(b)(8) is revised to reflect that OGE performance data, including maximum safe wind for the data presented, is no longer optional. Even though the new paragraph (a)(6) and the revised paragraph (b)(8) were not proposed, they only require the presentation in the Rotorcraft Flight Manual of the new OGE performance data, including the maximum wind for the data presented. The collection of the data is now required by the new § 29.49. New paragraph (a)(6) and revised paragraph (b)(8) state explicitly what would otherwise be required during the certification process to demonstrate compliance with the new required § 29.49. In addition to clarifying § 29.49(c), the new paragraph (a)(6) for Category A rotorcraft and the revised paragraph (b)(8) for Category B rotorcraft have identical provisions and additionally harmonize the FAR and the JAR. Based on these factors, the minimal burden placed on manufacturers of presenting the data that they are required to develop, and the remote likelihood of an adverse comment, it is unnecessary to solicit prior public comment on these nonsubstantive changes. Therefore, the proposal is adopted with the noted changes.

**Regulatory Evaluation Summary**

Changes to federal regulations must undergo several economic analyses. First, Executive Order 12866 directs Federal agencies to promulgate new regulations or modify existing regulations only if the potential benefits to society outweigh the potential costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic impact of regulatory changes on small entities. Finally, the Office of Management and Budget directs agencies to assess the effects of regulatory changes on international trade. In conducting these assessments, the FAA has determined that this rule: (1) Will generate benefits exceeding its costs and is not "significant" as defined in Executive Order 12866; (2) is not "significant" as defined in DOT's Policies and Procedures; (3) will not have a significant impact on a substantial number of small entities; and (4) will not impact international trade. These analyses, available in the docket, are summarized below.

*Cost/Benefit Analysis*

The rule includes 31 changes to 21 sections of part 29. Twenty eight of the changes are either editorial in nature or update the regulations to correspond with current technology. Three changes, as discussed below, were singled out for study because they are more substantive in terms of cost and/or benefit impact. The FAA has determined that these requirements will have no or negligible economic impacts on manufacturers and operators.

*Section 29.49(b)—Performance at Minimum Operating Speed (Category B Hover Performance).* This rule renumbers § 29.73 to 29.49, deletes paragraph (b)(2), and removes the minimum hover performance requirement for Category B helicopters (but still requires that hover performance data be developed and provided by the manufacturer). There will be no cost impact resulting from this change, since test requirements are unchanged and design changes are not required. Although the same amount of hover performance data will still be required from manufacturers, operators will benefit by being able to capitalize on a small increase in gross weight and payload.

*Section 29.49(c)—Performance at Minimum Operating Speed (Out-of-Ground Effect Hover Performance).* The rule will require that manufacturers provide out-of-ground effect (OGE) hover ceiling data to operators. Manufacturers have historically provided this information on a voluntary basis. Industry sources estimate that requiring OGE hover data will add, at most, an additional 3 to 5 flight test hours. At a cost of $24,800 per flight test hour, this represents an additional cost to manufacturers of $74,400 to $124,000 (in 1994 dollars) per certification.

OGE hover performance data is needed by operators that conduct external lift operations. If an operator were to conduct external lift operations without OGE hover data, the operator might pick up excessively heavy loads. While a single excessive load would not necessarily lead to an accident, it could create excessive stress on the dynamic components of the helicopter that could eventually lead to fatigue failure of a critical component and, subsequently, an accident. The expected benefit of averting a single accident entailing just one serious injury and/or moderate damage to the helicopter would easily exceed the upper-bound certification cost of $124,000.

Other advantages of requiring that manufacturers provide OGE hover data are that: (1) Operators will no longer be concerned that manufacturers might arbitrarily stop providing the data, (2) operators may feel more confident about the data because the FAA would be approving it, and (3) the FAA can assure uniformity in the presentation of data between manufacturers.

*Section 29.83—Landing: Category B.* The rule will require that approach and landing tests for Category B rotorcraft be made with power on rather than with engine power off. This is a more normal flight profile. This change will benefit pilots by providing more useful data in the flight manual for flight planning purposes since pilots normally plan for power-on landings. This will be particularly useful if a rotorcraft is operating at or near maximum gross weight in or around unimproved landing areas where landing distances are more critical. This will also increase the safety of test pilots since they will be required to perform fewer power-off tests. There are no or negligible additional costs associated with this change.

**Regulatory Flexibility Determination**

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by government regulations. The RFA requires a Regulatory Flexibility Analysis if a proposed or final rule would have a significant economic impact, either detrimental or beneficial, on a substantial number of small entities. FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, prescribes standards for complying with RFA review requirements in FAA rulemaking actions. The Order defines ''small entities'' in terms of size thresholds, ''significant economic impact'' in terms of annualized cost threshold, and ''substantial number'' as a number which is not less than eleven and which is more than one-third of the small entities subject to the proposed or final rule.

The rule will affect manufacturers and operators of future type-certificated transport category rotorcraft. For manufacturers, Order 2100.14A specifies a size threshold for classification as a small entity as 75 or fewer employees. Since no part 29 rotorcraft manufacturer has 75 or fewer employees, the rule will not have significant economic impact on a substantial number of small manufacturers. For operators, the benefits of increased payloads would probably not exceed the annualized thresholds specified in the Order; consequently, the rule will not have a significant economic impact on a substantial number of small operators.

**International Trade Impact**

The rule will have little or no impact on trade for either U.S. firms doing business in foreign markets or foreign firms doing business in the United States.

**Federalism Implications**

The regulations adopted herein will not have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that these amendments do not have sufficient federalism implications to warrant the preparation of a Federalism Assessment.

**Conclusion**

For the reasons discussed in the preamble, and based on the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not a significant regulatory action under Executive Order 12866. In addition, the FAA certifies that these changes will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. All changes are found to have negligible or no cost impacts. Small entities are not affected because transport rotorcraft are manufactured by large entities, and trade is not affected since foreign manufacturers also must comply with the requirements of part 29. This proposal is considered to be nonsignificant under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979). A regulatory evaluation of the changes, including a Regulatory Flexibility Determination and International Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under ''FOR FURTHER INFORMATION CONTACT.''

**The Amendment**

In consideration of the foregoing, the Federal Aviation Administration amends part 29 of Title 14, Code of Federal Regulations (14 CFR part 29) effective June 10, 1996.

The authority citation for part 29 continues to read as follows:

*Authority:* 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

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## Amendment 29–40

## Rotorcraft Regulatory Changes Based on European Joint Aviation Requirements

**Adopted: May 2, 1996** **Effective: August 8, 1996**

**(Published in 61 FR 21904, May 10, 1996)**
**(Corrected in 61 FR 29931, June 13, 1996)**

**SUMMARY:** The Federal Aviation Administration (FAA) is amending the airworthiness standards for normal and transport category rotorcraft. The changes revise airworthiness standards for performance, systems, propulsion, and airframes. The changes increase the regulatory safety level, clarify existing regulations, and standardize terminology. The changes are based on standards incorporated by the European Joint Aviation Authorities (JAA) for Joint Aviation Requirements (JAR) 27 and 29. These changes are intended to harmonize the U.S. rotorcraft airworthiness standards with the European JAR.

**FOR FURTHER INFORMATION CONTACT:** Carroll Wright, Regulations Group, Rotorcraft Directorate, Aircraft Certification Service, Federal Aviation Administration, Fort Worth, TX 76193–0111; telephone (817) 222–5120.

**SUPPLEMENTARY INFORMATION:**

### Background

These amendments are based on Notice of Proposed Rulemaking (NPRM) No. 94–36 published in the *Federal Register* on December 28, 1994 (59 FR 67068). That notice proposed to amend the airworthiness standards for both normal and transport category rotorcraft based on recommendations from the Aviation Rulemaking Advisory Committee (ARAC). By announcement in the *Federal Register* (57 FR 58846, December 11, 1992), the "JAR/FAR 27 and 29 Harmonization Working Group" was chartered by the ARAC. The working group included representatives from four major rotorcraft manufacturers (normal and transport) and representatives from Aerospace Industries Association of America, Inc. (AIA), Association Europeene des Constructeurs de Material Aerospatial (AECMA), Helicopter Association International (HAI), JAA, and the FAA Rotorcraft Directorate. This broad participation is consistent with FAA policy to involve all known interested parties as early as practicable in the rulemaking process.

The Harmonization Working Group was tasked with making recommendations to the ARAC regarding JAA Notices of Proposed Amendment (NPA's). The ARAC subsequently recommended that the FAA revise the airworthiness standards for normal and transport category rotorcraft to those currently in the JAR 27 and 29.

The FAA evaluated the ARAC recommendations and proposed changes to the rotorcraft airworthiness standards in 14 CFR parts 27 and 29 (parts 27 and 29). These proposed changes evolved from the FAA, JAA, and industry meetings of 1990–1992 and the ARAC recommendations of 1993. The changes proposed to (1) incorporate current design and testing practices into the rules by requiring additional performance data, (2) incorporate additional powerplant and rotor brake controls requirements, (3) incorporate bird-strike protection requirements, and (4) harmonize the certification requirements between parts 27 and 29 and the JAR. The proposals for part 27 included JAA's harmonized NPA's 27—Basic and 27–1, and the proposals for part 29 included NPA's 29—Basic and 29–1 through 29–5. This rule contains the harmonized rule language of those sections of the NPA's except for § 27.602 of NPA 27—Basic and § 29.602 of NPA 29–4.

In proposed rule, NPRM 94–36, there were several instances in which a few descriptive words were proposed to either be removed from or added to regulatory text. These word changes were adequately described in the amendatory language to NPRM 94–36 when that proposal was published in the *Federal Register.* However, at least one commenter misunderstood the amendatory language. Therefore, to avoid possible misunderstanding about the final rule language, the paragraphs with the minor rule language changes are reproduced in their entirety in this final rule. Also, the numbering of other regulations referenced in §§ 29.1587(a)(4) and (a)(5) has been changed, and a new § 29.1587(a)(6) has been added. The current § 29.1587(a)(6), which is being redesignated in this rule as § 29.1587(a)(7), was added by the recently published Transport Category Rotorcraft Performance Rule published elsewhere in this issue of the *Federal Register.*

In this final rule, under the heading ''Appendix C to Part 27—Criteria for Category A,'' the NPRM 94–36 cites to Advisory Circular (AC) material have been removed since AC material is advisory only. A note has been added that informs the reader that there is appropriate guidance material available. Further, the requirement to meet § 29.571 standards for certification as a part 27 Category A rotorcraft has been removed from the appendix C listing. The FAA has determined that the current § 27.571 contains sufficient certification standards to maintain an adequate level of safety for part 27 Category A rotorcraft, and an additional requirement of testing to § 29.571 standards is unnecessary.

**Discussion of Comments**

Interested persons have been afforded an opportunity to participate in the making of these amendments. Due consideration has been given to the comments received. Comments were received from the JAA, HAI, Transport Canada, and the United Kingdom Civil Aviation Authority (UKCAA).

The JAA agrees with the proposed rule and the effort to harmonize certification regulations of the U.S. and the European communities. To fulfill harmonization objectives, the JAA prepared an NPA identical to the NPRM and will publish the JAR final rule at the same time as this final rule for parts 27 and 29.

HAI comments that the proposals faithfully reflect the recommendation made to the FAA by the ARAC on rotorcraft regulatory changes. HAI further comments that the NPRM reflects prudent rulemaking to increase safety, economic viability, and harmonization within realistic requirements and urges the adoption of the proposal.

Transport Canada comments that the NPRM was not the same as the ARAC recommendations in that there were changes in the nonregulatory sections (preamble) and in the proposed text of the rule. The commenter states that these changes cause concern because the discrepancies may lead to different interpretations. The commenter notes that the meaning of § 29.547 was changed because the word ''main'' had been removed in the ARAC recommendations but was not removed in the NPRM. This commenter also states that the requirements of §§ 29.547 and 29.917 are redundant because § 29.571 also requires the identification of the principal structural elements (PSE) that includes rotors and rotor drive systems with the establishment of the inspections and replacement times for those PSE's. Additionally, the commenter says that § 29.610 should state that it addresses only ''direct effects'' of lightning and electricity and that indirect effects are covered elsewhere in §§ 29.954, 29.863, 29.1309, etc. This commenter also states that § 29.1309 should retain the reference to § 29.610. This commenter also suggests adding a new requirement and paragraph to appendix B to part 29 that would require an additional, self-powered third attitude indicator.

The FAA agrees with Transport Canada that editorial changes between the ARAC recommendations and the NPRM are a concern because the differences may lead to different interpretations. To obviate this concern, editorial changes have been made in the final rule language to make it consistent with the ARAC recommended language. Also, the FAA agrees with Transport Canada that the word ''main'' had been removed from the introductory paragraph of § 29.547(c), (d), and (e) in the ARAC recommended language but, as previously discussed, had not been shown as removed in the NPRM rule language. However, the word ''main'' is being removed from this final rule.

The FAA does not agree with this commenter that §§ 29.547, 29.571, and 29.917 are redundant in requiring identification of principal structural elements (PSE's), which include rotors and rotor drive systems, and the establishment of the inspections, replacement times of those PSE's. Section 29.547(b) requires a design assessment for main and tail rotor structure components (rotor hub, blades, pitch control mechanisms, etc); § 29.571 requires fatigue evaluation of structural components; and § 29.917 requires a design assessment of the rotor drive system (drive shafts, transmission, gearboxes, etc). Therefore, these are not redundant requirements. The language is adopted as proposed.

The FAA agrees with the intent of this commenter's suggestion that § 29.610 should clearly indicate that it addresses only ''direct effects'' of lightning and electricity. However, this was achieved in the NPRM by adding the word ''structure'' between the words ''rotorcraft'' and ''must'' in § 29.610(a) to clarify that this paragraph applied to rotorcraft structure and not to systems and equipment. Accordingly, the language is adopted as proposed.

The FAA does not agree with this commenter that § 29.1309 should retain the reference to § 29.610. The NPRM added the word ''structure'' to § 29.610 to clarify that the paragraph applied to rotorcraft structure and not to systems and equipment. Since § 29.1309(h) applies to lightning protection of systems and equipment, it is inappropriate to reference § 29.610, which applies to lightning protection of structures. The commenter's proposal to retain the reference to § 29.610 is not adopted.

The FAA disagrees with this commenter's suggestion that a new requirement and paragraph be added to part 29, appendix B, to require an additional, self-powered third attitude indicator. Part 29, appendix B, paragraph VIII(a)(2) currently requires a standby attitude indicator that is independent of the aircraft electrical generating system. Additionally, part 29, appendix B, paragraph VIII(b)(5)(iii) states, "The equipment, systems, and installations must be designed so that one display of the information essential to the safety of flight that is provided by the instruments will remain available to a pilot, without additional crew-member action, after any single failure or combination of failures that is not shown to be extremely improbable . . . ." Currently, the only practical design to meet the extremely improbable ($10^{-9}$) requirement of part 29, appendix B, for the display of information essential to flight safety after a single failure or combination of failures is the design that uses a third attitude indicator powered by a source other than the aircraft electrical generating system. However, the FAA does not wish to limit future alternative designs that may meet the extremely improbable standard without a third attitude indicator. The suggestion of the commenter to add a requirement for a self-powered third attitude indicator is not adopted.

The UKCAA comments that Proposal No. 13 in NPRM 94–36 proposed to amend § 29.923(b)(3)(i), to require two applications of 2-minute power following each application of 30-second power, instead of the one application of 2-minute power previously proposed. The UKCAA fully supports the proposed changes in NPRM 94–36. However, the UKCAA further comments that since publication of NPRM 94–36, the FAA published Amendment 29–34 (59 FR 47764, September 16, 1994) that states in part, "When conducted on a bench test, the test sequence must be conducted following stabilization at take-off power." The commenter states that the reason for adding this sentence, as stated in the preamble to Amendment 29–34, remains valid, and this sentence should therefore be included in the final rule developed from NPRM 94–36.

The FAA concurs with the UKCAA that the reason for adding the sentence, "When conducted on a bench test, the test sequence must be conducted following stabilization at take-off power" remains valid and the sentence should be retained in § 29.923(b)(3)(i). The sentence was adopted in Amendment 29–34 due to a commenter's statement that if the 5-minute takeoff power run to qualify the drive system is conducted as part of the endurance run, and the 30-second/2-minute OEI requirements are conducted on a bench test, then the takeoff power 5-minute run will be conducted twice on the same set of gears. The FAA did not intend to duplicate the takeoff power 5-minute run if the OEI requirements are conducted on a bench test, and the sentence was adopted for clarification. Since the omission of the sentence in NPRM 94–36 was inadvertent, since the reasons for including the sentence remain valid, and since the sentence is relieving in nature and does not place any additional burden on manufacturers, it is unnecessary to solicit prior public comment. Therefore, the sentence is restored as requested by the commenter.

After considering all of the comments, the FAA has determined that air safety and the pubic interest support adoption of the amendments with the changes noted.

## Regulatory Evaluation Summary

Proposed changes to federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, the Office of Management and Budget directs agencies to assess the effect of regulatory changes on international trade. In conducting these analyses, the FAA has determined that this rule: (1) would generate benefits that justify its costs and is not "a significant regulatory action" as defined in the Executive Order; (2) is nonsignificant as defined in DOT's Regulatory Policies and Procedures; (3) would not have a significant impact on substantial number of small entities; and (4) will lessen restraints on international trade. These analyses, available in the docket, are summarized below.

### *Cost-Benefit Analysis*

All of the changes to part 27 and all but four of the changes to part 29 will impose no or insignificant costs on rotorcraft manufacturers since they largely reflect current design practices. In recent years, manufacturers have incorporated engineering and structural improvements into rotorcraft designs that exceed minimum regulatory requirements with the aim of increasing operating efficiencies, payload capabilities, and marketability in world markets. Many of these improvements have also inherently improved safety. Codification of these improvement and other changes will ensure continuation of enhanced safety levels in future rotorcraft designs.

The changes will also increase harmonization and commonality between U.S. and European airworthiness standards. Harmonization will eliminate the need to comply with different FAA and JAA airworthiness requirements, thus reducing manufacturers' certification costs. Based on experience in a recent certification, one rotorcraft manufacturer indicated that complying with different FAA and JAA requirements resulted in several hundred thousand dollars of excessive certification costs (as related to all part 27 and 29 requirements). The duplicate certification costs avoided by the harmonized rule alone could outweigh the relatively modest increase in certification costs imposed by the few new requirements. Following is a summary of the four changes to part 29 that will impose additional costs totaling approximately $160,000 per type certification. The safety benefits of these changes are expected to easily exceed the incremental costs.

*Section 29.547—Main and tail rotor structure.* While manufacturers currently perform the design assessment as an integral part of the design requirements of § 29.917, there will be some incremental costs to formalize the existing information. These costs are included in the cost estimates of § 29.917 summarized below. Formal identification and assessment of critical component failures will increase safety by providing more comprehensive maintenance information to operators. The benefits of averting a single accident will exceed the relatively low incremental costs of compliance.

*Section 29.631—Bird strike.* Manufacturers indicate that present rotorcraft structures can withstand impacts with 2.2 pound birds; therefore, no incremental manufacturing costs are anticipated. Nonrecurring testing and analysis costs of the requirement are estimated to be $107,000 per type certification. A review of National Transportation Safety Board (NTSB) data for the period 1983–1991 reveals two rotorcraft accidents caused by bird strikes. One accident resulted in one serious injury, one minor injury, and substantial damage to the rotorcraft (tail rotor separation); in the other accident, the rotorcraft was destroyed but there were no injuries. There is at least an equal probability of such accidents in the future, given the tendencies toward higher operating speeds. The benefits of averting a single accident will exceed the incremental costs of the amendment.

*Section 29.917—Design.* The incremental costs to formalize existing design information for the rotor structure (§ 29.547 above) and drive system are estimated to total $47,000 per type certification. Formal identification and assessment of critical component failures of the rotor drive system will increase safety by providing more comprehensive maintenance information to operators. The benefits of averting a single accident caused directly or indirectly by a lack of relevant data would easily exceed the incremental costs.

*Section 29.1587—Performance information.* Since the required climb gradient data are already available from the results of flight tests required to obtain performance information, the only additional costs will be those associated with incorporating the data into the Flight Manual, estimated to total $6,000 per type certification. The availability and accuracy of performance data are paramount to operational safety. The benefits of averting a single accident caused directly or indirectly by a lack of relevant performance information will easily exceed the incremental costs.

## Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (RFA) was enacted by Congress to ensure that small entities are not unnecessarily and disproportionately burdened by Federal Regulations. The RFA requires a Regulatory Flexibility Analysis if a proposed rule would have "a significant economic impact on a substantial number of small entities." Based on the criteria of FAA Order 2100.14A, the FAA has determined that the rule will not have a significant impact on a substantial number of small entities.

The rule will affect manufacturers of future type-certificated normal (part 27) and transport category (part 29) rotorcraft. For manufacturers, Order 2100.14A defines a small entity as one with 75 or fewer employees and a significant economic impact as annualized costs of $19,000 or more. The FAA has determined that the rule will not have a significant economic impact on a substantial number of small manufacturers since (1) no part 29 and only two part 27 rotorcraft manufacturers have 75 or fewer employees, and (2) the annualized certification costs of the rule are less than $19,000.

## International Trade Impact Assessment

The rule will not constitute a barrier to international trade, including the export of American rotorcraft to other countries and the import of rotorcraft into the United States. Instead, the changes will harmonize with certification procedures of the JAA and thereby enhance free trade.

## Conclusion

For the reasons discussed above, including the findings in the Regulatory Flexibility Determination and the International Trade Impact Analysis, the FAA has determined that this regulation is not a significant regulatory action under Executive Order 12866. In addition, the FAA certifies that this regulation will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act. This regulation is considered nonsignificant under DOT Order 2100.5. A final regulatory evaluation of the regulation, including a final Regulatory Flexibility Determination and International Trade Impact Analysis, has been placed in the docket. A copy may be obtained by contacting the person identified under "FOR FURTHER INFORMATION CONTACT."

**The Amendments**

In consideration of the foregoing, the Federal Aviation Administration amends parts 27 and 29 of Title 14, Code of Federal Regulations (14 CFR parts 27 and 29) effective August 8, 1996.

The authority citation for part 29 continues to read as follows:

*Authority:* 49 U.S.C. 106(g), 40113, 44701, 44702, 44704.

# Part 29—Airworthiness Standards: Transport Category Rotorcraft
## Subpart A—General

### § 29.1 Applicability.

(a) This part prescribes airworthiness standards for the issue of type certificates, and changes to those certificates, for transport category rotorcraft.

(b) Transport category rotorcraft must be certificated in accordance with either the Category A or Category B requirements of this part. A multiengine rotorcraft may be type certificated as both Category A and Category B with appropriate and different operating limitations for each category.

(c) Rotorcraft with a maximum weight greater than 20,000 pounds and 10 or more passenger seats must be type certificated as Category A rotorcraft.

(d) Rotorcraft with a maximum weight greater than 20,000 pounds and nine or less passenger seats may be type certificated as Category B rotorcraft provided the Category A requirements of subparts C, D, E, and F of this part are met.

(e) [Rotorcraft with a maximum weight of 20,000 pounds or less but with 10 or more passenger seats may be type certificated as Category B rotorcraft provided the Category A requirements of §§ 29.67(a)(2), 29.87, 29.1517, and subparts C, D, E, and F of this part are met.]

(f) Rotorcraft with a maximum weight of 20,000 pounds or less and nine or less passenger seats may be type certificated as Category B rotorcraft.

(g) Each person who applies under part 21 for a certificate or change described in paragraphs (a) through (f) of this section must show compliance with the applicable requirements of this part.

(Amdt. 29–21, Eff. 3/2/83); [(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.2 Special retroactive requirements.

[For each rotorcraft manufactured after September 16, 1992, each applicant must show that each occupant's seat is equipped with a safety belt and shoulder harness that meets the requirements of paragraphs (a), (b), and (c) of this section.

[(a) Each occupant's seat must have a combined safety belt and shoulder harness with a single-point release. Each pilot's combined safety belt and shoulder harness must allow each pilot, when seated with safety belt and shoulder harness fastened, to perform all functions necessary for flight operations. There must be a means to secure belts and harnesses, when not in use, to prevent interference with the operation of the rotorcraft and with rapid egress in an emergency.

[(b) Each occupant must be protected from serious head injury by a safety belt plus a shoulder harness that will prevent the head from contacting any injurious object.

[(c) The safety belt and shoulder harness must meet the static and dynamic strength requirements, if applicable, specified by the rotorcraft type certification basis.

[(d) For purposes of this section, the date of manufacture is either—

[(1) The date the inspection acceptance records, or equivalent, reflect that the rotorcraft is complete and meets the FAA-Approved Type Design Data; or

[(2) The date that the foreign civil airworthiness authority certifies the rotorcraft is complete and issues an original standard airworthiness certificate, or equivalent, in that country.]

[(Amdt. 29–32, Eff. 9/16/91)]

# Subpart B—Flight

## GENERAL

### § 29.21 Proof of compliance.

Each requirement of this subpart must be met at each appropriate combination of weight and center of gravity within the range of loading conditions for which certification is requested. This must be shown—

(a) By tests upon a rotorcraft of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing; and

(b) By systematic investigation of each required combination of weight and center of gravity, if compliance cannot be reasonably inferred from combinations investigated.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.25 Weight limits.

(a) *Maximum weight.* The maximum weight (the highest weight at which compliance with each applicable requirement of this part is shown) or, at the option of the applicant, the highest weight for each altitude and for each practicably separable operating condition, such as takeoff, en route operation, and landing, must be established so that it is not more than—

(1) The highest weight selected by the applicant;

(2) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of this part is shown); or

(3) The highest weight at which compliance with each applicable flight requirement of this part is shown.

(b) *Minimum weight.* The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established so that it is not less than—

(1) The lowest weight selected by the applicant;

(2) The design minimum weight (the lowest weight at which compliance with each structural loading condition of this part is shown); or

(3) The lowest weight at which compliance with each applicable flight requirement of this part is shown.

(c) *Total weight with jettisonable external load.* A total weight for the rotorcraft with jettisonable external load attached that is greater than the maximum weight established under paragraph (a) of this section may be established if structural component approval for external load operations under part 133 of this chapter is requested and the following conditions are met:

(1) The portion of the total weight that is greater than the maximum weight established under paragraph (a) of this section is made up only of the weight of all or part of the jettisonable external load.

(2) Structural components of the rotorcraft are shown to comply with the applicable structural requirements of this part under the increased loads and stresses caused by the weight increase over that established under paragraph (a) of this section.

(3) Operation of the rotorcraft at a total weight greater than the maximum certificated weight established under paragraph (a) of this section is limited by appropriate operating limitations to rotorcraft external load operations under part 133 of this chapter.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.27 Center of gravity limits.

The extreme forward and aft centers of gravity and, where critical, the extreme lateral centers of gravity must be established for each weight established under § 29.25. Such an extreme may not lie beyond—

(a) The extremes selected by the applicant;

(b) The extremes within which the structure is proven; or

(c) The extremes within which compliance with the applicable flight requirements is shown.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.29 Empty weight and corresponding center of gravity.

(a) The empty weight and corresponding center of gravity must be determined by weighing the rotorcraft without the crew and payload, but with—

(1) Fixed ballast;

(2) Unusable fuel; and

(3) Full operating fluids, including—

(i) Oil;

(ii) Hydraulic fluid; and

(iii) Other fluids required for normal operation of rotorcraft systems, except water intended for injection in the engines.

(b) The condition of the rotorcraft at the time of determining empty weight must be one that is well defined and can be easily repeated, particularly with respect to the weights of fuel, oil, coolant, and installed equipment.

[(Amdt. 29–15, Eff. 3/1/78)]

### § 29.31 Removable ballast.

Removable ballast may be used in showing compliance with the flight requirements of this subpart.

### § 29.33 Main rotor speed and pitch limits.

(a) *Main rotor speed limits.* A range of main rotor speeds must be established that—

(1) With power on, provides adequate margin to accommodate the variations in rotor speed occurring in any appropriate maneuver, and is consistent with the kind of governor or synchronizer used; and

(2) With power off, allows each appropriate autorotative maneuver to be performed throughout the ranges of airspeed and weight for which certification is requested.

(b) *Normal main rotor high pitch limits (power on).* For rotorcraft, except helicopters required to have a main rotor low speed warning under paragraph (e) of this section, it must be shown, with power on and without exceeding approved engine maximum limitations, that main rotor speeds substantially less than the minimum approved main rotor speed will not occur under any sustained flight condition. This must be met by—

(1) Appropriate setting of the main rotor high pitch stop;

(2) Inherent rotorcraft characteristics that make unsafe low main rotor speeds unlikely; or

(3) Adequate means to warn the pilot of unsafe main rotor speeds.

(c) *Normal main rotor low pitch limit (power off).* It must be shown, with power off, that—

(1) The normal main rotor low pitch limit provides sufficient rotor speed, in any autorotative condition, under the most critical combinations of weight and airspeed; and

(2) It is possible to prevent overspeeding of the rotor without exceptional piloting skill.

(d) *Emergency high pitch.* If the main rotor high pitch stop is set to meet paragraph (b)(1) of this section, and if that stop cannot be exceeded inadvertently, additional pitch may be made available for emergency use.

(e) *Main rotor low speed warning for helicopters.* For each single engine helicopter, and each multiengine helicopter that does not have an approved device that automatically increases power on the operating engines when one engine fails, there must be a main rotor low speed warning which meets the following requirements:

(1) The warning must be furnished to the pilot in all flight conditions, including power-on and power-off flight, when the speed of a main rotor approaches a value that can jeopardize safe flight.

(2) The warning may be furnished either through the inherent aerodynamic qualities of the helicopter or by a device.

(3) The warning must be clear and distinct under all conditions, and must be clearly distinguishable from all other warnings. A visual device that requires the attention of the crew within the cockpit is not acceptable by itself.

(4) If a warning device is used, the device must automatically deactivate and reset when the low-speed condition is corrected. If the device has an audible warning, it must also be equipped with a means for the pilot to manually silence the audible warning before the low-speed condition is corrected.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–15, Eff. 3/1/78)]

## PERFORMANCE

### § 29.45 General.

(a) The performance prescribed in this subpart must be determined—

(1) With normal piloting skill; and

(2) Without exceptionally favorable conditions.

(b) Compliance with the performance requirements of this subpart must be shown—

(1) For still air at sea level with a standard atmosphere; and

(2) For the approved range of atmospheric variables.

(c) The available power must correspond to engine power, not exceeding the approved power, less—

(1) Installation losses; and

(2) The power absorbed by the accessories and services at the values for which certification is requested and approved.

(d) For reciprocating engine-powered rotorcraft, the performance, as affected by engine power, must be based on a relative humidity of 80 percent in a standard atmosphere.

(e) For turbine engine-powered rotorcraft, the performance, as affected by engine power, must be based on a relative humidity of—

(1) 80 percent, at and below standard temperature; and

(2) 34 percent, at and above standard temperature plus 50 degrees F.

Between these two temperatures, the relative humidity must vary linearly.

(f) For turbine-engine-powered rotorcraft, a means must be provided to permit the pilot to determine prior to takeoff that each engine is capable of developing the power necessary to achieve the applicable rotorcraft performance prescribed in this subpart.

[(Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–24, Eff. 12/6/84)]

### [§ 29.49 Performance at minimum operating speed.

[(a) For each Category A helicopter, the hovering performance must be determined over the ranges of weight, altitude, and temperature for which takeoff data are scheduled—

(1) With not more than takeoff power;

(2) With the landing gear extended; and

(3) At a height consistent with the procedure used in establishing the takeoff, climbout, and rejected takeoff paths.

[(b) For each Category B helicopter, the hovering performance must be determined over the ranges of weight, altitude, and temperature for which certification is requested, with—

(1) Takeoff power;

(2) The landing gear extended; and

(3) The helicopter in ground effect at a height consistent with normal takeoff procedures.

[(c) For each helicopter, the out-of-ground effect hovering performance must be determined over the ranges of weight, altitude, and temperature for which certification is requested with takeoff power.

[(d) For rotorcraft other than helicopters, the steady rate of climb at the minimum operating speed must be determined over the ranges of weight, altitude, and temperature for which certification is requested with—

(1) Takeoff power; and

(2) The landing gear extended.]

(Amdt. 29–3, Eff. 2/25/68 in § 29.73); [(Amdt. 29–39, Eff. 6/10/96)]

### § 29.51 Takeoff data: General.

(a) [The takeoff data required by §§ 29.53, 29.55, 29.59, 29.60, 29.61, 29.62, 29.63, and 29.67 must be determined—]

(1) At each weight, altitude, and temperature selected by the applicant; and

(2) With the operating engines within approved operating limitations.

(b) Takeoff data must—

(1) Be determined on a smooth, dry, hard surface; and

(2) Be corrected to assume a level takeoff surface.

(c) No takeoff made to determine the data required by this section may require exceptional piloting skill or alertness, or exceptionally favorable conditions.

[(Amdt. 29–39, Eff. 6/10/96)]

### § 29.53 Takeoff: Category A.

[The takeoff performance must be determined and scheduled so that, if one engine fails at any time after the start of takeoff, the rotocraft can—

(a) [Return to, and stop safely on, the takeoff area; or

(b) [Continue the takeoff and climbout, and attain a configuration and airspeed allowing compliance with § 29.67(a)(2).]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.55 Takeoff decision point (TDP): Category A.

[(a) The TDP is the first point from which a continued takeoff capability is assured under § 29.59 and is the last point in the takeoff path from which a rejected takeoff is assured within the distance determined under §29.62.

[(b) The TDP must be established in relation to the takeoff path using no more than two parameters; e.g., airspeed and height, to designate the TDP.

[(c) Determination of the TDP must include the pilot recognition time interval following failure of the critical engine.]

[(Amdt. 29–39, Eff. 6/10/96)]

### § 29.59 Takeoff path: Category A.

(a) [The takeoff path extends from the point of commencement of the takeoff procedure to a point at which the rotorcraft is 1,000 feet above the takeoff surface and compliance with § 29.67(a)(2) is shown. In addition—

(1) The takeoff path must remain clear of the height-velocity envelope established in accordance with § 29.87;

(2) The rotocraft must be flown to the engine failure point; at which point, the critical engine must be made inoperative and remain inoperative for the rest of the takeoff;

(3) After the critical engine is made inoperative, the rotorcraft must continue to the takeoff decision point, and then attain $V_{TOSS}$;

(4) Only primary controls may be used while attaining $V_{TOSS}$ and while establishing a positive rate of climb. Secondary controls that are located on the primary controls may be used after a positive rate of climb and $V_{TOSS}$ are established but in no case less than 3 seconds after the critical engine is made inoperative; and

(5) After attaining $V_{TOSS}$ and a positive rate of climb, the landing gear may be retracted.

(b) [During the takeoff path determination made in accordance with paragraph (a) of this section and after attaining $V_{TOSS}$ and a positive rate of climb, the climb must be continued at a speed as close as practicable to, but not less than, $V_{TOSS}$ until the rotocraft is 200 feet above the takeoff surface. During this interval, the climb performance must meet or exceed that required by § 29.67(a)(1).

(c) [From 200 feet above the takeoff surface, the rotorcraft takeoff path must be level or positive until a height 1,000 feet above the takeoff surface is attained with not less than the rate of climb required by § 29.67(a)(2). Any secondary or auxiliary control may be used after attaining 200 feet above the takeoff surface.

[(d) Takeoff distance will be determined in accordance with § 29.61.

[(e) During the continued takeoff, the rotorcraft shall not descend below 15 feet above the takeoff surface when the takeoff decision point is above 15 feet.]

(Amdt. 29–24, Eff. 12/6/84); [(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.60 Elevated heliport takeoff path: Category A.

[(a) The elevated heliport takeoff path extends from the point of commencement of the takeoff procedure to a point in the takeoff path at which the rotorcraft is 1,000 feet above the takeoff surface and compliance with § 29.67(a)(2) is shown. In addition—

(1) The requirements of § 29.59(a) must be met;

(2) While attaining $V_{TOSS}$ and a positive rate of climb, the rotocraft may descend below the level of the takeoff surface if, in so doing and when clearing the elevated heliport edge, every part of the rotocraft clears all obstacles by at least 15 feet;

(3) The vertical magnitude of any descent below the takeoff surface must be determined; and

(4) After attaining $V_{TOSS}$ and a positive rate of climb, the landing gear may be retracted.

[(b) The scheduled takeoff weight must be such that the climb requirements of § 29.67(a)(1) and (a)(2) will be met.

[(c) Takeoff distance will be determined in accordance with § 29.61.]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.61 Takeoff distance: Category A.

[(a) The normal takeoff distance is the horizontal distance along the takeoff path from the start of the takeoff to the point at which the rotorcraft attains and remains at least 35 feet above the takeoff surface, attains and maintains a speed of at least $V_{TOSS}$, and establishes a positive rate of climb, assuming the critical engine failure occurs at the engine failure point prior to the takeoff decision point.

[(b) For elevated heliports, the takeoff distance is the horizontal distance along the takeoff path from the start of the takeoff to the point at which the rotorcraft attains and maintains a speed of at least $V_{TOSS}$ and establishes a positive rate of climb, assuming the critical engine failure occurs at the engine failure point prior to the takeoff decision point.]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.62 Rejected takeoff: Category A.

[The rejected takeoff distance and procedures for each condition where takeoff is approved will be established with—

[(a) The takeoff path requirements of §§ 29.59 and 29.60 being used up to the engine failure point, the rotorcraft continuing to takeoff decision point, and the rotorcraft landed and brought to a stop on the takeoff surface;

[(b) The remaining engines operating within approved limits;

[(c) The landing gear remaining extended throughout the entire rejected takeoff; and

[(d) The use of only the primary controls until the rotorcraft is on the ground. Secondary controls located on the primary control may not be used until the rotorcraft is on the ground. Means other than wheel brakes may be used to stop the rotorcraft if the means are safe and reliable and consistent results can be expected under normal operating conditions.]

[(Amdt. 29–39, Eff. 6/10/96)]

### § 29.63 Takeoff: Category B.

The horizontal distance required to take off and climb over a 50-foot obstacle must be established with the most unfavorable center of gravity. The takeoff may be begun in any manner if—

(a) The takeoff surface is defined;

(b) Adequate safeguards are maintained to ensure proper center of gravity and control positions; and

(c) A landing can be made safely at any point along the flight path if an engine fails.

[(Amdt. 29–12, Eff. 2/1/77)]

### [§ 29.64 Climb: General.

[Compliance with the requirements of §§ 29.65 and 29.67 must be shown at each weight, altitude, and temperature within the operational limits established for the rotorcraft and with the most unfavorable center of gravity for each configuration. Cowl flaps, or other means of controlling the engine-cooling air supply, will be in the position that provides adequate cooling at the temperatures and altitudes for which certification is requested.]

[(Amdt. 29–39, Eff. 6/10/96)]

### § 29.65 Climb: All engines operating.

(a) [The steady rate of climb must be determined—

(1) [With maximum continuous power;

(2) [With the landing gear retracted; and

(3) [A $V_y$ for standard sea level conditions and at speeds selected by the applicant for other conditions.]

(b) For each Category B rotorcraft except helicopters, the rate of climb determined under paragraph (a) of this section must provide a steady climb gradient of at least 1:6 under standard sea level conditions.

(Amdt. 29–15, Eff. 3/1/78); [(Amdt. 29–39, Eff. 6/10/96)]

### § 29.67 Climb: One-engine-inoperative [(OEI)].

(a) [For Category A rotorcraft, in the critical takeoff configuration existing along the takeoff path, the following apply:

(1) The steady rate of climb without ground effect, 200 feet above the takeoff surface, must be at least 100 feet per minute for each weight, altitude, and temperature for which takeoff data are to be scheduled with—

(i) The critical engine inoperative and the remaining engines within approved operating limitations, except that for rotorcraft for which the use of 30-second/2-minute OEI power is requested, only the 2-minute OEI power may be used in showing compliance with this paragraph;

(ii) The landing gear extended; and

(iii) The takeoff safety speed selected by the applicant.

(2) The steady rate of climb without ground effect at 1,000 feet above the takeoff surface must be at least 150 feet per minute for each weight altitude, and temperature for which takeoff data are to be scheduled with—

(i) The critical engine inoperative and the remaining engines at maximum continuous power including OEI maximum continuous power, if approved, or at 30-minute power for rotorcraft for which certification for use of 30-minute power is requested;

(ii) The most unfavorable center of gravity for climb following takeoff;

(iii) The landing gear retracted; and

(iv) The speed selected by the applicant.

(3) The steady rate of climb (or descent) in feet per minute, at each altitude and temperature

at which the rotocraft is expected to operate and at any weight within the range of weights for which certification is requested, must be determined with—

(i) The critical engine inoperative and the remaining engines at maximum continuous power including OEI maximum continuous power, if approved, and at 30-minute power for rotorcraft for which certification for the use of 30-minute power is requested;

(ii) The landing gear retracted; and

(iii) The speed selected by the applicant.

(b) [For multiengine Category B rotorcraft meeting the Category A engine isolation requirements, the steady rate of climb (or descent) must be determined at the speed for best rate of climb (or minimum rate of descent) at each altitude, temperature, and weight at which the rotorcraft is expected to operate, with the critical engine inoperative and the remaining engines at maximum continuous power including OEI maximum continuous power, if approved, and at 30-minute power for rotorcraft for which certification for the use of 30-minute power is requested.]

(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–24, Eff. 12/6/84); (Amdt. 29–26, Eff. 10/3/88); (Amdt. 29–34, Eff. 10/17/94); [(Amdt. 29–39, Eff. 6/10/96)]

### § 29.71 Helicopter angle of glide: Category B.

For each category B helicopter, except multiengine helicopters meeting the requirements of § 29.67(b) and the powerplant installation requirements of category A, the steady angle of glide must be determined in autorotation—

(a) At the forward speed for minimum rate of descent as selected by the applicant;

(b) At the forward speed for best glide angle;

(c) At maximum weight; and

(d) At the rotor speed or speeds selected by the applicant.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.75 [Landing: General.

(a) [For each rotorcraft—

(1) The corrected landing data must be determined for a smooth, dry, hard, and level surface;

(2) The approach and landing must not require exceptional piloting skill or exceptionally favorable conditions; and

(3) The landing must be made without excessive vertical acceleration or tendency to bounce, nose over, ground loop, porpoise, or water loop.

(b) [The landing data required by §§ 29.77, 29.79, 29.81, 29.83, and 29.85 must be determined—

(1) At each weight, altitude, and temperature for which landing data are approved;

(2) With each operating engine within approved operating limitations; and

(3) With the most unfavorable center of gravity.]

(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–17, Eff. 12/1/78); [(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.77 Landing decision point: Category A.

[The landing decision point (LDP) must be established at not less than the last point in the approach and landing path at which a balked landing can be accomplished under § 29.85 with the critical engine failed or failing and with the engine failure recognized by the pilot.]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.79 Landing: Category A.

[(a) For Category A rotorcraft—

(1) The landing performance must be determined and scheduled so that if the critical engine fails at any point in the approach path, the rotorcraft can either land and stop safely or climb out and attain a rotorcraft configuration and speed allowing compliance with the climb requirement of § 29.67(a)(2);

(2) The approach and landing paths must be established with the critical engine inoperative so that the transition between each stage can be made smoothly and safely;

(3) The approach and landing speeds must be selected by the applicant and must be appropriate to the type of rotorcraft; and

(4) The approach and landing path must be established to avoid the critical areas of the height-velocity envelope determined in accordance with § 29.87.

[(b) It must be possible to make a safe landing on a prepared landing surface after complete power failure occurring during normal cruise.]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.81 Landing distance: Category A.

[The horizontal distance required to land and come to a complete stop (or to a speed of approximately 3 knots for water landings) from a point 50 feet above the landing surface (25 feet for Category A elevated heliport landing operations) must be determined from the approach and landing paths established in accordance with § 29.79.]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.83 Landing: Category B.

[(a) For each Category B rotorcraft, the horizontal distance required to land and come to a complete stop (or to a speed of approximately 3 knots for water landings) from a point 50 feet above the landing surface must be determined with—

(1) Speeds appropriate to the type of rotocraft and chosen by the applicant to avoid the critical areas of the height-velocity envelope established under § 29.87; and

(2) The approach and landing made with power on and within approved limits.

[(b) Each multiengine Category B rotorcraft that meets the powerplant installation requirements for Category A must meet the requirements of—

(1) Sections 29.79 and 29.81; or

(2) Paragraph (a) of this section.

[(c) It must be possible to make a safe landing on a prepared landing surface if complete power failure occurs during normal cruise.]

[(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.85] Balked landing: Category A.

[For Category A rotocraft, the balked landing path must be established so that—

(a) [With the critical engine inoperative, the transition from each stage of the maneuver to the next stage can be made smoothly and safely;

(b) [With the critical engine failed and the failure recognized at the landing decision point on the approach path selected by the applicant, a safe climbout can be made at speeds allowing compliance with the climb requirements of § 29.67(a)(1) and (2); and

(c) [The rotocraft does not descend below 15 feet above the landing surface. For elevated heliport operations, descent may be below the level of the landing surface provided the deck edge clearance of § 29.60 is maintained and the descent distance below the landing surface is determined.]

(Amdt. 29–24, Eff. 12/6/84); [(Amdt. 29–39, Eff. 6/10/96)]

### [§ 29.87] Height-velocity envelope.

(a) [If there is any combination of height and forward velocity (including hover) under which a safe landing cannot be made after failure of the critical engine and with the remaining engines (where applicable) operating within approved limits, a height-velocity envelope must be established for—

(1) All combinations of pressure altitude and ambient temperature for which takeoff and landing are approved; and

(2) Wright from the maximum weight (at sea level) to the highest weight approved for takeoff and landing at each altitude. For helicopters, this weight need not exceed the highest weight allowing hovering out-of-ground effect at each altitude.

(b) [For single-engine or multiengine rotorcraft that do not meet the Category A engine isolation requirements, the height-velocity envelope for complete power failure must be established.]

(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–21, Eff. 3/2/83); [(Amdt. 29–39, Eff. 6/10/96)]

## FLIGHT CHARACTERISTICS

### § 29.141 General.

The rotorcraft must—

(a) Except as specifically required in the applicable section, meet the flight characteristics requirements of this subpart—

(1) At the approved operating altitudes and temperatures;

(2) Under any critical loading condition within the range of weights and centers of gravity for which certification is requested; and

(3) For power-on operations, under any condition of speed, power, and rotor r.p.m. for which certification is requested; and

(4) For power-off operations, under any condition of speed and rotor r.p.m. for which certification is requested that is attainable with the controls rigged in accordance with the approved rigging instructions and tolerances;

(b) Be able to maintain any required flight condition and make a smooth transition from any flight condition to any other flight condition without exceptional piloting skill, alertness, or strength, and without danger of exceeding the limit load factor under any operating condition probable for the type, including—

(1) Sudden failure of one engine, for multiengine rotorcraft meeting transport category A engine isolation requirements;

(2) Sudden, complete power failure, for other rotorcraft; and

(3) Sudden, complete control system failures specified in § 29.695 of this part; and

(c) Have any additional characteristics required for night or instrument operation, if certification for those kinds of operation is requested. Requirements for helicopter instrument flight are contained in appendix B of this part.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–21, Eff. 3/2/83); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.143 Controllability and maneuverability.

(a) The rotorcraft must be safely controllable and maneuverable—

(1) During steady flight; and

(2) During any maneuver appropriate to the type, including—

(i) Takeoff;

(ii) Climb;

(iii) Level flight;

(iv) Turning flight;

(v) Glide; and

(vi) Landing (power on and power off).

(b) The margin of cyclic control must allow satisfactory roll and pitch control at $V_{NE}$ with—

(1) Critical weight;

(2) Critical center of gravity;

(3) Critical rotor r.p.m.; and

(4) Power off (except for helicopters demonstrating compliance with paragraph (e) of this section) and power on.

(c) A wind velocity of not less than 17 knots must be established in which the rotorcraft can be operated without loss of control on or near the ground in any manner appropriate to the type (such as crosswind takeoffs, sideward flight, and rearward flight), with—

(1) Critical weight;

(2) Critical center of gravity; and

(3) Critical motor r.p.m.

(d) The rotorcraft, after (1) failure of one engine, in the case of multiengine rotorcraft that meet transport category A engine isolation requirements, or (2) complete power failure in the case of other rotorcraft, must be controllable over the range of speeds and altitudes for which certification is requested when such power failures occurs with maximum continuous power and critical weight. No corrective action time delay for any condition following power failure may be less than—

(i) For the cruise condition, one second, or normal pilot reaction time (whichever is greater); and

(ii) For any other condition, normal pilot reaction time.

(e) For helicopters for which a $V_{NE}$ (power-off) is established under § 29.1505(c), compliance must be demonstrated with the following requirements with critical weight, critical center of gravity, and critical rotor r.p.m.:

(1) The helicopter must be safely slowed to $V_{NE}$ (power-off), without exceptional pilot skill after the last operating engine is made inoperative at power-on $V_{NE}$.

(2) At a speed of 1.1 $V_{NE}$ (power-off), the margin of cyclic control must allow satisfactory roll and pitch control with power off.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.151 Flight controls.

(a) Longitudinal, lateral, directional, and collective controls may not exhibit excessive breakout force, friction, or preload.

(b) Control system forces and free play may not inhibit a smooth, direct rotorcraft response to control system input.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.161 Trim control.

The trim control—

(a) Must trim any steady longitudinal, lateral, and collective control forces to zero in level flight at any appropriate speed; and

(b) May not introduce any undesirable discontinuities in control force gradients.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.171 Stability: General.

The rotorcraft must be able to be flown, without undue pilot fatigue or strain, in any normal maneuver for a period of time as long as that expected in normal operation. At least three landings and takeoffs must be made during this demonstration.

### § 29.173 Static longitudinal stability.

(a) The longitudinal control must be designed so that a rearward movement of the control is necessary to obtain a speed less than the trim speed, and a forward movement of the control is necessary to obtain a speed more than the trim speed.

(b) With the throttle and collective pitch held constant during the maneuvers specified in § 29.175(a) through (c), the slope of the control position versus speed curve must be positive throughout the full range of altitude for which certification is requested.

(c) During the maneuver specified in § 29.175(d), the longitudinal control position versus speed curve may have a negative slope within the specified speed range if the negative motion is not greater than 10 percent of total control travel.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.175 Demonstration of static longitudinal stability.

(a) *Climb.* Static longitudinal stability must be shown in the climb condition at speeds from 0.85 $V_Y$ or 15 knots below $V_Y$, whichever is less, to 1.2 $V_Y$ or 15 knots above $V_Y$, whichever is greater, with—

(i) Critical weight;

(2) Critical center of gravity;

(3) Maximum continuous power;

(4) The landing gear retracted; and

(5) The rotorcraft trimmed at $V_Y$.

(b) *Cruise.* Static longitudinal stability must be shown in the cruise condition at speeds from 0.7 $V_H$ or 0.7 $V_{NE}$, whichever is less to 1.1 $V_H$ or 1.1 $V_{NE}$, whichever is less, with—

(1) Critical weight;

(2) Critical center of gravity;

(3) Power for level flight at 0.9 $V_H$ or 0.9 $V_{NE}$, whichever is less;

(4) The landing gear retracted; and

(5) The rotorcraft trimmed at 0.9 $V_H$ or 0.9 $V_{NE}$, whichever is less.

(c) *Autorotation.* Static longitudinal stability must be shown in autorotation at airspeeds from 0.5 times the speed for minimum rate of descent, or 0.5 times the maximum range glide speed for Category A rotorcraft, to $V_{NE}$: or to 1.1 $V_{NE}$ (power-off) if $V_{NE}$ (power-off) is established under § 29.1505(c), and with—

(1) Critical weight;

(2) Critical center of gravity;

(3) Power off;

(4) The landing gear—

(i) Retracted;

(ii) Extended; and

(5) The rotorcraft trimmed at appropriate speeds found necessary by the Administrator to demonstrate stability throughout the prescribed speed range.

(d) *Hovering.* For helicopters, the longitudinal cyclic control must operate with the sense, direction of motion, and position as prescribed in § 29.173 between the maximum approved rearward speed and a forward speed of 17 knots with—

(1) Critical weight;

(2) Critical center of gravity;

(3) Power required to maintain an approximate constant height in ground effect;

(4) The landing gear extended; and

(5) The helicopter trimmed for hovering.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.177 Static directional stability.

Static directional stability must be positive with throttle and collective controls held constant at the trim conditions specified in § 29.175(a), (b), and (c). Sideslip angle must increase steadily with directional control deflection for sideslip angles up to ±10° from trim. Sufficient cues must accompany sideslip to alert the pilot when approaching sideslip limits.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.181 Dynamic stability: Category A rotorcraft.

Any short-period oscillation occurring at any speed from $V_Y$ to $V_{NE}$ must be positively damped with the primary flight controls free and in a fixed position.

[(Amdt. 29–24, Eff. 12/6/84)]

## GROUND AND WATER HANDLING CHARACTERISTICS

### § 29.231 General.

The rotorcraft must have satisfactory ground and water handling characteristics, including freedom from uncontrollable tendencies in any condition expected in operation.

### § 29.235 Taxiing condition.

The rotorcraft must be designed to withstand the loads that would occur when the rotorcraft is taxied over the roughest ground that may reasonably be expected in normal operation.

### § 29.239 Spray characteristics.

If certification for water operation is requested, no spray characteristics during taxiing, takeoff, or landing may obscure the vision of the pilot or damage the rotors, propellers, or other parts of the rotorcraft.

### § 29.241 Ground resonance.

The rotorcraft may have no dangerous tendency to oscillate on the ground with the rotor turning.

## MISCELLANEOUS FLIGHT REQUIREMENTS

### § 29.251 Vibration.

Each part of the rotorcraft must be free from excessive vibration under each appropriate speed and power condition.

# Subpart C—Strength Requirements

## GENERAL

### § 29.301 Loads.

(a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the rotorcraft. These loads must be distributed to closely approximate or conservatively represent actual conditions.

(c) If deflections under load would significantly change the distribution of external or internal loads, this redistribution must be taken into account.

### § 29.303 Factor of safety.

Unless otherwise provided, a factor of safety of 1.5 must be used. This factor applies to external and inertia loads unless its application to the resulting internal stresses is more conservative.

### § 29.305 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental or permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure. This must be shown by—

(1) Applying ultimate loads to the structure in a static test for at least 3 seconds; or

(2) Dynamic tests simulating actual load application.

### § 29.307 Proof of structure.

(a) Compliance with the strength and deformation requirements of this subpart must be shown for each critical loading condition accounting for the environment to which the structure will be exposed in operation. Structural analysis (static or fatigue) may be used only if the structure conforms to those structures for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made.

(b) Proof of compliance with the strength requirements of this subpart must include—

(1) Dynamic and endurance tests of rotors, rotor drives, and rotor controls;

(2) Limit load tests of the control system, including control surfaces;

(3) Operation tests of the control system;

(4) Flight stress measurement tests;

(5) Landing gear drop tests; and

(6) Any additional tests required for new or unusual design features.

[(Amdt. 29–4, Eff. 10/17/68); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.309 Design limitations.

The following values and limitations must be established to show compliance with the structural requirements of this subpart:

(a) The design maximum and design minimum weights.

(b) The main rotor r.p.m. ranges, power on and power off.

(c) The maximum forward speeds for each main rotor r.p.m. within the ranges determined under paragraph (b) of this section.

(d) The maximum rearward and sideward flight speeds.

(e) The center of gravity limits corresponding to the limitations determined under paragraphs (b), (c), and (d) of this section.

(f) The rotational speed ratios between each powerplant and each connected rotating component.

(g) The positive and negative limit maneuvering load factors.

## FLIGHT LOADS

### § 29.321 General.

(a) The flight load factor must be assumed to act normal to the longitudinal axis of the rotorcraft, and to be equal in magnitude and opposite in direction to the rotorcraft inertia load factor at the center of gravity.

(b) Compliance with the flight load requirements of this subpart must be shown—

(1) At each weight from the design minimum weight to the design maximum weight; and

(2) With any practical distribution of disposable load within the operating limitations in the Rotorcraft Flight Manual.

### § 29.337 Limit maneuvering load factor.

The rotorcraft must be designed for—

(a) A limit maneuvering load factor ranging from a positive limit of 3.5 to a negative limit of $-1.0$; or

(b) Any positive limit maneuvering load factor not less than 2.0 and any negative limit maneuvering load factor of not less than $-0.5$ for which—

(1) The probability of being exceeded is shown by analysis and flight tests to be extremely remote; and

(2) The selected values are appropriate to each weight condition between the design maximum and design minimum weights.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.339 Resultant limit maneuvering loads.

The loads resulting from the application of limit maneuvering load factors are assumed to act at the center of each rotor hub and at each auxiliary lifting surface, and to act in directions and with distributions of load among the rotors and auxiliary lifting surfaces, so as to represent each critical maneuvering condition, including power-on and power-off flight with the maximum design rotor tip speed ratio. The rotor tip speed ratio is the ratio of the rotorcraft flight velocity component in the plane of the rotor disc to the rotational tip speed of the rotor blades, and is expressed as follows:

$$\mu = \frac{V \cos a}{\Omega R}$$

where—

$V$ = The airspeed along the flight path (f.p.s.);

$a$ = The angle between the projection, in the plane of symmetry, of the axis of no feathering and a line perpendicular to the flight path (radians, positive when axis is pointing aft);

$\Omega$ = The angular velocity of rotor (radians per second); and

$R$ = The rotor radius (ft.).

### § 29.341 Gust loads.

Each rotorcraft must be designed to withstand, at each critical airspeed including hovering, the loads resulting from vertical and horizontal gusts of 30 feet per second.

### § 29.351 Yawing conditions.

(a) Each rotorcraft must be designed for the loads resulting from the maneuvers specified in paragraphs (b) and (c) of this section, with—

(1) Unbalanced aerodynamic moments about the center of gravity which the aircraft reacts to in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces; and

(2) Maximum main rotor speed.

(b) To produce the load required in paragraph (a) of this section, in unaccelerated flight with zero yaw, at forward speeds from zero up to 0.6 $V_{NE}$—

(1) Displace the cockpit control suddenly to the maximum deflection limited by the control stops or by the maximum pilot force specified in § 29.395(a);

(2) Attain a resulting sideslip angle or 90°, whichever is less; and

(3) Return the directional control suddenly to neutral.

(c) To produce the load required in paragraph (a) of the section, in unaccelerated flight with zero yaw, at forward speeds from 0.6 $V_{NE}$ up to $V_{NE}$ or $V_H$, whichever is less—

(1) Displace the cockpit directional control suddenly to the maximum deflection limited by the control stops or by the pilot force specified in § 29.395(a);

(2) Attain a resulting sideslip angle or 15°, whichever is less, at the lesser speed of $V_{NE}$ or $V_H$;

(3) Vary the sideslip angles of paragraphs (b)(2) and (c)(2) of this section directly with speed; and

(4) Return the directional control suddenly to neutral.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.361 Engine torque.

The limit engine torque may not be less than the following:

(a) For turbine engines, the highest of—

(1) The mean torque for maximum continuous power multiplied by 1.25;

(2) The torque required by § 29.923;

(3) The torque required by § 29.927; or

(4) The torque imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

(b) For reciprocating engines, the mean torque for maximum continuous power multiplied by—

(1) 1.33, for engines with five or more cylinders; and

(2) Two, three, and four, for engines with four, three, and two cylinders, respectively.

[(Amdt. 29–26, Eff. 10/3/88)]

## CONTROL SURFACE AND SYSTEM LOADS

### § 29.391 General.

Each auxiliary rotor, each fixed or movable stabilizing or control surface, and each system operating any flight control must meet the requirements of §§ 29.395 through 29.403, 29.411, 29.413, and 29.427.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.395 Control system.

(a) The reaction to the loads prescribed in § 29.397 must be provided by—

(1) The control stops only;

(2) The control locks only;

(3) The irreversible mechanism only (with the mechanism locked and with the control surface in the critical positions for the effective parts of the system within its limit of motion);

(4) The attachment of the control system to the rotor blade pitch control horn only (with the control in the critical positions for the affected parts of the system within the limits of its motion); and

(5) The attachment of the control system to the control surface horn (with the control in the critical positions for the affected parts of the system within the limits of its motion).

(b) Each primary control system, including its supporting structure, must be designed as follows:

(1) The system must withstand loads resulting from the limit pilot forces prescribed in § 29.397;

(2) Notwithstanding paragraph (b)(3) of this section, when power-operated actuator controls or power boost controls are used, the system must also withstand the loads resulting from the limit pilot forces prescribed in § 29.397 in conjunction with the forces output of each normally energized power device, including any single power boost or actuator system failure;

(3) If the system design or the normal operating loads are such that a part of the system cannot react to the limit pilot forces prescribed in § 29.397, that part of the system must be designed to withstand the maximum loads that can be obtained in normal operation. The minimum design loads must, in any case, provide a rugged system for service use, including consideration of fatigue, jamming, ground gusts, control inertia, and friction loads. In the absence of a rational analysis, the design loads resulting from 0.60 of the specified limit pilot forces are acceptable minimum design loads; and

(4) If operational loads may be exceeded through jamming, ground gusts, control inertia, or friction, the system must withstand the limit pilot forces specified in § 29.397, without yielding.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.397 Limit pilot forces and torques.

(a) Except as provided in paragraph (b) of this section, the limit pilot forces are as follows:

(1) For foot controls, 130 pounds.

(2) For stick controls, 100 pounds fore and aft, and 67 pounds laterally.

(b) For flap, tab, stabilizer, rotor brake, and landing gear operating controls, the following apply (R=radius in inches):

(1) Crank, wheel, and lever controls, [1+R]/3×50 pounds, but not less than 50 pounds nor more than 100 pounds for hand operated controls or 130 pounds for foot operated controls, applied at any angle within 20 degrees of the plane of motion of the control.

(2) Twist controls, 80R pounds.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.399 Dual control system.

Each dual primary flight control system must be able to withstand the loads that result when pilot forces not less than 0.75 times those obtained under § 29.395 are applied—

(a) In opposition; and

(b) In the same direction.

### § 29.401 [Removed]

### § 29.403 [Removed]

### § 29.411 Ground clearance: Tail rotor guard.

(a) It must be impossible for the tail rotor to contact the landing surface during a normal landing.

(b) If a tail rotor guard is required to show compliance with paragraph (a) of this section—

(1) Suitable design loads must be established for the guard; and

(2) The guard and its supporting structure must be designed to withstand those loads.

### § 29.413 [Removed]

### § 29.427 Unsymmetrical loads.

(a) Horizontal tail surfaces and their supporting structure must be designed for unsymmetrical loads arising from yawing and rotor wake effects in combination with the prescribed flight conditions.

(b) To meet the design criteria of paragraph (a) of this section, in the absence of more rational data, both of the following must be met:

(1) One hundred percent of the maximum loading from the symmetrical flight conditions acts on the surface on one side of the plane of symmetry, and no loading acts on the other side.

(2) Fifty percent of the maximum loading from the symmetrical flight conditions acts on the surface on each side of the plane of symmetry, in opposite directions.

(c) For empennage arrangements where the horizontal tail surfaces are supported by the vertical tail surfaces, the vertical tail surfaces and supporting structure must be designed for the combined vertical and horizontal surface loads resulting from each prescribed flight condition, considered separately. The flight conditions must be selected so that the maximum design loads are obtained on each surface. In the absence of more rational data, the unsymmetrical horizontal tail surface loading distributions described in this section must be assumed.

[(Amdt. 29–30, Eff. 4/5/90); (Amdt. 29–31, Eff. 10/22/90)]

## GROUND LOADS

### § 29.471 General.

(a) *Loads and equilibrium.* For limit ground loads—

(1) The limit ground loads obtained in the landing conditions in this part must be considered to be external loads that would occur in the rotorcraft structure if it were acting as a rigid body; and

(2) In each specified landing condition, the external loads must be placed in equilibrium with linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centers of gravity.* The critical centers of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element.

### § 29.473 Ground loading conditions and assumptions.

(a) For specified landing conditions, a design maximum weight must be used that is not less than the maximum weight. A rotor lift may be assumed to act through the center of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight.

(b) Unless otherwise prescribed, for each specified landing condition, the rotorcraft must be designed for a limit load factor of not less than the limit inertia load factor substantiated under § 29.725.

(c) Triggering or actuating devices for additional or supplementary energy absorption may not fail under loads established in the tests prescribed in §§ 29.725 and 29.727, but the factor of safety prescribed in § 29.303 need not be used.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.475 Tires and shock absorbers.

Unless otherwise prescribed, for each specified landing condition, the tires must be assumed to be in their static position and the shock absorbers to be in their most critical position.

### § 29.477 Landing gear arrangement.

Sections 29.235, 29.479 through 29.485, and 29.493 apply to landing gear with two wheels aft, and one or more wheels forward, of the center of gravity.

### § 29.479 Level landing conditions.

(a) *Attitudes.* Under each of the loading conditions prescribed in paragraph (b) of this section, the rotorcraft is assumed to be in each of the following level landing attitudes:

(1) An attitude in which each wheel contacts the ground simultaneously.

(2) An attitude in which the aft wheels contact the ground with the forward wheels just clear of the ground.

(b) *Loading conditions.* The rotorcraft must be designed for the following landing loading conditions:

(1) Vertical loads applied under § 29.471.

(2) The loads resulting from a combination of the loads applied under paragraph (b)(1) of this section with drag loads at each wheel of not less than 25 percent of the vertical load at that wheel.

(3) The vertical load at the instant of peak drag load combined with a drag component simulating the forces required to accelerate the wheel rolling assembly up to the specified ground speed, with—

(i) The ground speed for determination of the spin-up loads being at least 75 percent of the optimum forward flight speed for minimum rate of descent in autorotation; and

(ii) The loading conditions of paragraph (b) applied to the landing gear and its attaching structure only.

(4) If there are two wheels forward, a distribution of the loads applied to those wheels under paragraphs (b)(1) and (2) of this section in a ratio of 40:60.

(c) *Pitching moments.* Pitching moments are assumed to be resisted by—

(1) In the case of the attitude in paragraph (a)(1) of this section, the forward landing gear; and

(2) In the case of the attitude in paragraph (a)(2) of this section, the angular inertia forces.

### § 29.481 Tail-down landing conditions.

(a) The rotorcraft is assumed to be in the maximum nose-up attitude allowing ground clearance by each part of the rotorcraft.

(b) In this attitude, ground loads are assumed to act perpendicular to the ground.

### § 29.483 One-wheel landing conditions.

For the one-wheel landing condition, the rotorcraft is assumed to be in the level attitude and to contact the ground on one aft wheel. In this attitude—

(a) The vertical load must be the same as that obtained on that side under § 29.479(b)(1); and

(b) The unbalanced external loads must be reacted by rotorcraft inertia.

### § 29.485 Lateral drift landing conditions.

(a) The rotorcraft is assumed to be in the level landing attitude, with—

(1) Side loads combined with one-half of the maximum ground reactions obtained in the level landing conditions of § 29.479(b)(1); and

(2) The loads obtained under paragraph (a)(1) of this section applied—

(i) At the ground contact point; or

(ii) For full-swiveling gear, at the center of the axle.

(b) The rotorcraft must be designed to withstand, at ground contact—

(1) When only the aft wheels contact the ground, side loads of 0.8 times the vertical reaction acting inward on one side and 0.6 times the vertical reaction acting outward on the other side, all combined with the vertical loads specified in paragraph (a) of this section; and

(2) When the wheels contact the ground simultaneously—

(i) For the aft wheels, the side loads specified in paragraph (b)(1) of this section; and

(ii) For the forward wheels, a side load of 0.8 times the vertical reaction combined with the vertical load specified in paragraph (a) of this section.

### § 29.493 Braked roll conditions.

Under braked roll conditions with the shock absorbers in their static positions—

(a) The limit vertical load must be based on a load factor of at least—

(1) 1.33, for the attitude specified in § 29.479(a)(1); and

(2) 1.0, for the attitude specified in § 29.479(a)(2); and

(b) The structure must be designed to withstand, at the ground contact point of each wheel with brakes, a drag load of at least the lesser of—

(1) The vertical load multiplied by a coefficient of friction of 0.8; and

(2) The maximum value based on limiting brake torque.

### § 29.497 Ground loading conditions: Landing gear with tail wheels.

(a) *General.* Rotorcraft with landing gear with two wheels forward and one wheel aft of the center of gravity must be designed for loading conditions as prescribed in this section.

(b) *Level landing attitude with only the forward wheels contacting the ground.* In this attitude—

(1) The vertical loads must be applied under §§ 29.471 through 29.475;

(2) The vertical load at each axle must be combined with a drag load at that axle of not less than 25 percent of that vertical load; and

(3) Unbalanced pitching moments are assumed to be resisted by angular inertia forces.

(c) *Level landing attitude with all wheels contacting the ground simultaneously.* In this attitude, the rotorcraft must be designed for landing loading conditions as prescribed in paragraph (b) of this section.

(d) *Maximum nose-up attitude with only the rear wheel contacting the ground.* The attitude for this condition must be the maximum nose-up attitude expected in normal operation, including autorotative landings. In this attitude—

(1) The appropriate ground loads specified in paragraph (b)(1) and (2) of this section must be determined and applied, using a rational method to account for the moment arm between the rear wheel ground reaction and the rotorcraft center of gravity; or

(2) The probability of landing with initial contact on the rear wheel must be shown to be extremely remote.

(e) *Level landing attitude with only forward wheel contacting the ground.* In this attitude, the rotorcraft must be designed for ground loads as specified in paragraph (b)(1) and (3) of this section.

(f) *Side loads in the level landing attitude.* In the attitudes specified in paragraphs (b) and (c) of this section, the following apply:

(1) The side loads must be combined at each wheel with one-half of the maximum vertical ground reactions obtained for that wheel under paragraphs (b) and (c) of this section. In this condition, the side loads must be—

(i) For the forward wheels, 0.8 times the vertical reaction (on one side) acting inward, and 0.6 times the vertical reaction (on the other side) acting outward; and

(ii) For the rear wheel, 0.8 times the vertical reaction.

(2) The loads specified in paragraph (f)(1) of this section must be applied—

(i) At the ground contact point with the wheel in the trailing position (for non full swiveling landing gear or for full swiveling landing gear with a lock, steering device, or shimmy damper to keep the wheel in the trailing position); or

(ii) At the center of the axle (for full swiveling landing gear without a lock, steering device, or shimmy damper).

(g) *Braked roll conditions in the level landing attitude.* In the attitudes specified in paragraphs (b) and (c) of this section, and with the shock absorbers in their static positions, the rotorcraft must be designed for braked roll loads as follows:

(1) The limit vertical load must be based on a limit vertical load factor of not less than—

(i) 1.0, for the attitude specified in paragraph (b) of this section; and

(ii) 1.33, for the attitude specified in paragraph (c) of this section.

(2) For each wheel with brakes, a drag load must be applied, at the ground contact point, of not less than the lesser of—

(i) 0.8 times the vertical load; and

(ii) The maximum based on limiting brake torque.

(h) *Rear wheel turning loads in the static ground attitude.* In the static ground attitude, and with the shock absorbers and tires in their static positions, the rotorcraft must be designed for rear wheel turning loads as follows:

(1) A vertical ground reaction equal to the static load on the rear wheel must be combined with an equal side load.

(2) The load specified in paragraph (h)(1) of this section must be applied to the rear landing gear—

(i) Through the axle, if there is a swivel (the rear wheel being assumed to be swiveled 90° to the longitudinal axis of the rotorcraft); or

(ii) At the ground contact point if there is a lock, steering device or shimmy damper (the rear wheel being assumed to be in the trailing position).

(i) *Taxiing condition.* The rotorcraft and its landing gear must be designed for the loads that would occur when the rotorcraft is taxied over the roughest ground that may reasonably be expected in normal operation.

### § 29.501 Ground loading conditions: Landing gear with skids.

(a) *General.* Rotorcraft with landing gear with skids must be designed for the loading conditions specified in this section. In showing compliance with this section, the following apply:

(1) The design maximum weight, center of gravity, and load factor must be determined under §§ 29.471 through 29.475.

(2) Structural yielding of elastic spring members under limit loads is acceptable.

(3) Design ultimate loads for elastic spring members need not exceed those obtained in a drop test of the gear with—

(i) A drop height of 1.5 times that specified in § 29.725; and

(ii) An assumed rotor lift of not more than 1.5 times that used in the limit drop tests prescribed in § 29.725.

(4) Compliance with paragraphs (b) through (e) of this section must be shown with—

(i) The gear in its most critically deflected position for the landing condition being considered; and

(ii) The ground reactions rationally distributed along the bottom of the skid tube.

(b) *Vertical reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the vertical reactions must be applied as prescribed in paragraph (a) of this section.

(c) *Drag reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical reactions must be combined with horizontal drag reactions of 50 percent of the vertical reaction applied at the ground.

(2) The resultant ground loads must equal the vertical load specified in paragraph (b) of this section.

(d) *Sideloads in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical ground reaction must be—

(i) Equal to the vertical loads obtained in the condition specified in paragraph (b) of this section; and

(ii) Divided equally among the skids.

(2) The vertical ground reactions must be combined with a horizontal sideload of 25 percent of their value.

(3) The total sideload must be applied equally between skids and along the length of the skids.

(4) The unbalanced moments are assumed to be resisted by angular inertia.

(5) The skid gear must be investigated for—

(i) Inward acting sideloads; and

(ii) Outward acting sideloads.

(e) *One-skid landing loads in the level attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of one skid only, the following apply:

(1) The vertical load on the ground contact side must be the same as that obtained on that side in the condition specified in paragraph (b) of this section.

(2) The unbalanced moments are assumed to be resisted by angular inertia.

(f) *Special conditions.* In addition to the conditions specified in paragraphs (b) and (c) of this section, the rotorcraft must be designed for the following ground reactions:

(1) A ground reaction load acting up and aft at an angle of 45° to the longitudinal axis of the rotorcraft. This load must be—

(i) Equal to 1.33 times the maximum weight;

(ii) Distributed symmetrically among the skids;

(iii) Concentrated at the forward end of the straight part of the skid tube; and

(iv) Applied only to the forward end of the skid tube and its attachment to the rotorcraft.

(2) With the rotorcraft in the level landing attitude, a vertical ground reaction load equal to one-half of the vertical load determined under paragraph (b) of this section. This load must be—

(i) Applied only to the skid tube and its attachment to the rotorcraft; and

(ii) Distributed equally over 33.3 percent of the length between the skid tube attachments and centrally located midway between the skid tube attachments.

**[**(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–30, Eff. 4/5/90)**]**

### § 29.505 Ski landing conditions.

If certification for ski operation is requested, the rotorcraft with skis, must be designed to withstand the following loading conditions (where $P$ is the maximum static weight on each ski with the rotorcraft at design maximum weight, and $n$ is the limit load factor determined under § 29.473(b)):

(a) Up-load conditions in which—

(1) A vertical load of $Pn$ and a horizontal load of $Pn/4$ are simultaneously applied at the pedestal bearings; and

(2) A vertical load of 1.33 $P$ is applied at the pedestal bearings.

(b) A side load condition in which a side load of 0.35 $Pn$ is applied at the pedestal bearings in a horizontal plane perpendicular to the centerline of the rotorcraft.

(c) A torque-load condition in which a torque load of 1.33 *P* (in foot-pounds) is applied to the ski about the vertical axis through the centerline of the pedestal bearings.

### 29.511 Ground load: Unsymmetrical loads on multiple-wheel units.

(a) In dual-wheel gear units, 60 percent of the total ground reaction for the gear unit must be applied to one wheel and 40 percent to the other.

(b) To provide for the case of one deflated tire, 60 percent of the specified load for the gear unit must be applied to either wheel except that the vertical ground reaction may not be less than the full static value.

(c) In determining the total load on a gear unit, the transverse shift in the load centroid, due to unsymmetrical load distribution on the wheels, may be neglected.

[(Amdt. 29–3, Eff. 2/25/68)]

## WATER LOADS

### § 29.519 Hull type rotorcraft: Water-based and amphibian.

(a) *General.* For hull type rotorcraft, the structure must be designed to withstand the water loading set forth in paragraphs (b), (c), and (d) of this section considering the most severe wave heights and profiles for which approval is desired. The loads for the landing conditions of paragraphs (b) and (c) of this section must be developed and distributed along and among the hull and auxiliary floats, if used, in a rational and conservative manner, assuming a rotor lift not exceeding two-thirds of the rotorcraft weight to act throughout the landing impact.

(b) *Vertical landing conditions.* The rotorcraft must initially contact the most critical wave surface at zero forward speed in likely pitch and roll attitudes which result in critical design loadings. The vertical descent velocity may not be less than 6.5 feet per second relative to the mean water surface.

(c) *Forward speed landing conditions.* The rotorcraft must contact the most critical wave at forward velocities from zero up to 30 knots in likely pitch, roll, and yaw attitudes and with a vertical descent velocity of not less than 6.5 feet per second relative to the mean water surface. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out landing.

(d) *Auxiliary float immersion condition.* In addition to the loads from the landing conditions, the auxiliary float, and its support and attaching structure in the hull, must be designed for the load developed by a fully immersed float unless it can be shown that full immersion of the float is unlikely, in which case the highest likely float buoyancy load must be applied that considers loading of the float immersed to create restoring moments compensating for upsetting moments caused by side wind, asymmetrical rotorcraft loading, water wave action, and rotorcraft inertia.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.521 Float landing conditions.

If certification for float operation (including float amphibian operation) is requested, the rotorcraft, with floats, must be designed to withstand the following loading conditions (where the limit load factor is determined under § 29.473(b) or assumed to be equal to that determined for wheel landing gear):

(a) Up-load conditions in which—

(1) A load is applied so that, with the rotorcraft in the static level attitude, the resultant water reaction passes vertically through the center of gravity; and

(2) The vertical load prescribed in paragraph (a)(1) of this section is applied simultaneously with an aft component of 0.25 times the vertical component.

(b) A side load condition in which—

(1) A vertical load of 0.75 times the total vertical load specified in paragraph (a)(1) of this section is divided equally among the floats; and

(2) For each float, the load share determined under paragraph (b)(1) of this section, combined with a total side load of 0.25 times the total vertical load specified in paragraph (b)(1) of this section, is applied to that float only.

[(Amdt. 29–3, Eff. 2/25/68)]

## MAIN COMPONENT REQUIREMENTS

### § 29.547 [Main and tail rotor structure.]

[(a) A rotor is an assembly of rotating components, which includes the rotor hub, blades, blade dampers, the pitch control mechanisms, and all other parts that rotate with the assembly.

[(b) Each rotor assembly must be designed as prescribed in this section and must function safely for the critical flight load and operating conditions. A design assessment must be performed, including a detailed failure analysis to identify all failures that will prevent continued safe flight or safe landing, and must identify the means to minimize the likelihood of their occurrence.

[(c) The rotor structure must be designed to withstand the following loads prescribed in §§ 29.337 through 29.341 and 29.351:]

(1) Critical flight loads.

(2) Limit loads occurring under normal conditions of autorotation.

(d) [The rotor structure must be designed to withstand loads simulating—]

(1) For the rotor blades, hubs, and flapping hinges, the impact force of each blade against its stop during ground operation; and

(2) Any other critical condition expected in normal operation.

(e) [The rotor structure must be designed to withstand the limit torque at any rotational speed, including zero.

In addition:]

(1) The limit torque need not be greater than the torque defined by a torque limiting device (where provided), and may not be less than the greater of—

(i) The maximum torque likely to be transmitted to the rotor structure, in either direction, by the rotor drive or by sudden application of the rotor brake; and

(ii) [For the main rotor, the limit engine torque specified in § 29.361.]

(2) The limit torque must be equally and rationally distributed to the rotor blades.

(Amdt. 29–4, Eff. 10/17/68); [(Amdt. 29–40, Eff. 8/8/96)]

### § 29.549 Fuselage and rotor pylon structures.

(a) Each fuselage and rotor pylon structure must be designed to withstand—

(1) The critical loads prescribed in §§ 29.337 through 29.341, and 29.351;

(2) The applicable ground loads prescribed in §§ 29.235, 29.471 through 29.485, 29.493, 29.497, 29.505, and 29.521; and

(3) The loads prescribed in § 29.547(d)(1) and (e)(1)(i).

(b) Auxiliary rotor thrust, the torque reaction of each rotor drive system, and the balancing air and inertia loads occurring under accelerated flight conditions, must be considered.

(c) Each engine mount and adjacent fuselage structure must be designed to withstand the loads occurring under accelerated flight and landing conditions, including engine torque.

(d) [Reserved]

(e) If approval for the use of 2½-minute OEI power is requested, each engine mount and adjacent structure must be designed to withstand the loads resulting from a limit torque equal to 1.25 times the mean torque for 2½-minute power OEI combined with 1g flight loads.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–4, Eff. 10/17/68); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.551 Auxiliary lifting surfaces.

Each auxiliary lifting surface must be designed to withstand—

(a) The critical flight loads in §§ 29.337 through 29.341, and 29.351;

(b) The applicable ground loads in §§ 29.235, 29.471 through 29.485, 29.493, 29.505, and 29.521; and

(c) Any other critical condition expected in normal operation.

## EMERGENCY LANDING CONDITIONS

### § 29.561 General.

(a) The rotorcraft, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this section to protect the occupants under those conditions.

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a crash landing when—

(1) Proper use is made of seats, belts, and other safety design provisions;

(2) The wheels are retracted (where applicable); and

(3) Each occupant and each item of mass inside the cabin that could injure an occupant is restrained when subjected to the following ultimate inertial load factors relative to the surrounding structure:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g, after the intended displacement of the seat device.

[(v) Rearward—1.5g.]

(c) The supporting structure must be designed to restrain under any ultimate inertial load factor up to those specified in this paragraph, any item of mass above and/or behind the crew and passenger compartment that could injure an occupant if it came loose in an emergency landing. Items of mass to be considered include, but are not limited to, rotors, transmission, and engines. The items of mass must be restrained for the following ultimate inertial load factors:

(1) Upward—1.5g.

(2) Forward—[12g.]

(3) Sideward—[6g.]

(4) Downward—[12g.]

[(5) Rearward—1.5g.]

(d) Any fuselage structure in the area of internal fuel tanks below the passenger floor level must be designed to resist the following ultimate inertial factors and loads, and to protect the fuel tanks from rupture, if rupture is likely when those loads are applied to that area:

(1) Upward—1.5g.

(2) Forward—4.0g.

(3) Sideward—2.0g.

(4) Downward—4.0g.

(Amdt. 29–4, Eff. 10/17/68); (Amdt. 29–29, Eff. 12/13/89); [(Amdt. 29–38, Eff. 6/11/96)]

### § 29.562 Emergency landing dynamic conditions.

(a) The rotorcraft, although it may be damaged in a crash landing, must be designed to reasonably protect each occupant when—

(1) The occupant properly uses the seats, safety belts, and shoulder harnesses provided in the design; and

(2) The occupant is exposed to loads equivalent to those resulting from the conditions prescribed in this section.

(b) Each seat type design or other seating device approved for crew or passenger occupancy during takeoff and landing must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar type seat in accordance with the following criteria. The test must be conducted with an occupant simulated by a 170-pound anthropomorphic test dummy (ATD), as defined by 49 CFR 572, subpart B, or its equivalent, sitting in the normal upright position.

(1) A change in downward velocity of not less than 30 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is canted upward 60° with respect to the impact velocity vector, and the rotorcraft's lateral axis is perpendicular to a vertical plane containing the impact velocity vector and the rotorcraft's longitudinal axis. Peak floor deceleration must occur in not more than 0.031 seconds after impact and must reach a minimum of 30g's.

(2) A change in forward velocity of not less than 42 feet per second when the seat or other seating device is oriented in its nominal position with respect to the rotorcraft's reference system, the rotorcraft's longitudinal axis is yawed 10° either right or left of the impact velocity vector (whichever would cause the greatest load on the shoulder harness), the rotorcraft's lateral axis is contained in a horizontal plane containing the impact velocity vector, and the rotorcraft's vertical axis is perpendicular to a horizontal plane containing the impact velocity vector. Peak floor deceleration must occur in not more than 0.071 seconds after impact and must reach a minimum of 18.4g's.

(3) When floor rails or floor or sidewall floor attachment devices are used to attach the seating devices to the airframe structure for the conditions of this section, the rails or devices must be misaligned with respect to each other by at least 10° vertically (i.e., pitch out of parallel) and by at least a 10° lateral roll, with the directions optional, to account for possible floor warp.

(c) Compliance with the following must be shown:

(1) The seating device system must remain intact although it may experience separation intended as part of its design.

(2) The attachment between the seating device and the airframe structure must remain intact although the structure may have exceeded its limit load.

(3) The ATDs shoulder harness strap or straps must remain on or in the immediate vicinity of the ATDs shoulder during the impact.

(4) The safety belt must remain on the ATDs pelvis during the impact.

(5) The ATDs head either does not contact any portion of the crew or passenger compartment or, if contact is made, the head impact does not exceed a head injury criteria (HIC) of 1,000 as determined by this equation.

$$HIC=(t_2-t_1)\left[\frac{1}{(t_2-t_1)}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}$$

Where—

a(t) is the resultant acceleration at the center of gravity of the head form expressed as a multiple of g (the acceleration of gravity) and $t_2 - t_1$ is the time duration, in seconds, of major head impact, not to exceed 0.05 seconds.

(6) Loads in individual shoulder harness straps must not exceed 1,750 pounds. If dual straps are used for retaining the upper torso, the total harness strap loads must not exceed 2,000 pounds.

(7) The maximum compressive load measured between the pelvis and the lumbar column of the ATD must not exceed 1,500 pounds.

(d) An alternate approach that achieves an equivalent or greater level of occupant protection, as required by this section, must be substantiated on a rational basis.

[(Amdt. 29–29, Eff. 12/13/89)]

### § 29.563 Structural ditching provisions.

If certification with ditching provisions is requested, structural strength for ditching must meet the requirements of this section and § 29.801(e).

(a) *Forward speed landing conditions.* The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 30 knots in likely pitch, roll, and yaw attitudes. The rotorcraft limit vertical descent velocity may not be less than 5 feet per second relative to the mean water surface. Rotor lift may be used to act through the center of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight. A maximum forward velocity of less than 30 knots may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal one-engine-out touchdown.

(b) *Auxiliary or emergency float conditions.*

(1) *Floats fixed or deployed before initial water contact.* In addition to the landing loads in paragraph (a) of this section, each auxiliary or emergency float, or its support and attaching structure in the airframe or fuselage, must be designed for the load developed by a fully immersed float unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest. likely float buoyancy load must be applied. The highest likely buoyancy load must include consideration of a partially immersed float creating restoring moments to compensate the upsetting moments caused by side wind, unsymmetrical rotorcraft loading, water wave action, rotorcraft inertia, and probable structural damage and leakage considered under § 29.801(d). Maximum roll and pitch angles determined from compliance with § 29.801(d) may be used, if significant, to determine the extent of immersion of each float. If the floats are deployed in flight, appropriate air loads derived from the flight limitations with the floats deployed shall be used in substantiation of the floats and their attachment to the rotorcraft. For this purpose, the design airspeed for limit load is the float deployed airspeed operating limit multiplied by 1.11.

(2) *Floats deployed after initial water contact.* Each float must be designed for full or partial immersion prescribed in paragraph (b)(1) of this section. In addition, each float must be designed for combined vertical and drag loads using a relative limit speed of 20 knots between the rotorcraft and the water. The vertical load may not be less than the highest likely buoyancy load determined under paragraph (b)(1) of this section.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–30, Eff. 4/5/90)]

## FATIGUE EVALUATION

### § 29.571 Fatigue evaluation of structure.

(a) *General.* An evaluation of the strength of principal elements, detail design points, and fabrication techniques must show that catastrophic failure due to fatigue, considering the effects of environment, intrinsic/discrete flaws, or accidental damage will be avoided. Parts to be evaluated include, but are not limited to, rotors, rotor drive systems between the engines and rotor hubs, controls, fuselage, fixed and movable control surfaces, engine and transmission mountings, landing gear, and their related primary attachments. In addition, the following apply:

(1) Each evaluation required by this section must include—

(i) The identification of principal structural elements, the failure of which could result in catastrophic failure of the rotorcraft;

(ii) In-flight measurement in determining the loads or stresses for items in paragraph (a)(1)(i) of this section in all critical conditions throughout the range of limitations in § 29.309 (including altitude effects), except that maneuvering load factors need not exceed the maximum values expected in operations; and

(iii) Loading spectra as severe as those expected in operation based on loads or stresses determined under paragraph (a)(1)(ii) of this section, including external load operations, if applicable, and other high frequency power cycle operations.

(2) Based on the evaluations required by this section, inspections, replacement times, combinations thereof, or other procedures must be established as necessary to avoid catastrophic failure. These inspections, replacement times, combinations thereof, or other procedures must be included in the airworthiness limitations section of the Instructions for Continued Airworthiness required by § 29.1529 and Section A29.4 of appendix A of this part.

(b) *Fatigue tolerance evaluation (including tolerance to flaws).* The structure must be shown by analysis supported by test evidence and, if available, service experience to be of fatigue tolerant design. The fatigue tolerance evaluation must include the requirements of either paragraph (b)(1), (2), or (3) of this section, or a combination thereof, and also must include a determination of the probable locations and modes of damage caused by fatigue, considering environmental effects, intrinsic/discrete flaws, or accidental damage. Compliance with the flaw tolerance requirements of paragraph (b)(1) or (2) of this section is required unless the applicant establishes that these fatigue flaw tolerant methods for a particular structure cannot be achieved within the limitations of geometry, inspectability, or good design practice. Under these circumstances, the safe-life evaluation of paragraph (b)(3) of this section is required.

(1) *Flaw tolerant safe-life evaluation.* It must be shown that the structure, with flaws present, is able to withstand repeated loads of variable magnitude without detectable flaw growth for the following time intervals—

(i) Life of the rotorcraft; or

(ii) Within a replacement time furnished under Section A29.4 of appendix A to this part.

(2) *Fail-safe (residual strength after flaw growth) evaluation.* It must be shown that the structure remaining after a partial failure is able to withstand design limit loads without failure within an inspection period furnished under Section A29.4 of appendix A to this part. Limit loads are defined in § 29.301(a).

(i) The residual strength evaluation must show that the remaining structure after flaw growth is able to withstand design limit loads without failure within its operational life.

(ii) Inspection intervals and methods must be established as necessary to ensure that failures are detected prior to residual strength conditions being reached.

(iii) If significant changes in structural stiffness or geometry, or both, follow from a structural failure or partial failure, the effect on flaw tolerance must be further investigated.

(3) *Safe-life evaluation.* It must be shown that the structure is able to withstand repeated loads of variable magnitude detectable cracks for the following time intervals—

(i) Life of the rotorcraft; or

(ii) Within a replacement time furnished under Section A29.4 of appendix A to this part.

[(Amdt. 29–4, Eff. 10/17/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–20, Eff. 10/14/80); (Amdt. 29–28, Eff. 11/27/89)]

# Subpart D—Design and Construction

## GENERAL

### § 29.601 Design.

(a) The rotorcraft may have no design features or details that experience has shown to be hazardous or unreliable.

(b) The suitability of each questionable design detail and part must be established by tests.

### § 29.603 Materials.

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must—

(a) Be established on the basis of experience or tests;

(b) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–17, Eff. 12/1/78)]

### § 29.605 Fabrication methods.

(a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed according to an approved process specification.

(b) Each new aircraft fabrication method must be substantiated by a test program.

[(Amdt. 29–17, Eff. 12/1/78)]

### § 29.607 Fasteners.

(a) Each removable bolt, screw, nut, pin, or other fastener whose loss could jeopardize the safe operation of the rotorcraft must incorporate two separate locking devices. The fastener and its locking devices may not be adversely affected by the environmental conditions associated with the particular installation.

(b) No self-locking nut may be used on any bolt subject to rotation in operation unless a non-friction locking device is used in addition to the self-locking device.

[(Amdt. 29–5, Eff. 10/27/68)]

### § 29.609 Protection of structure.

Each part of the structure must—

(a) Be suitably protected against deterioration or loss of strength in service due to any cause, including—

(1) Weathering;

(2) Corrosion; and

(3) Abrasion; and

(b) Have provisions for ventilation and drainage where necessary to prevent the accumulation of corrosive, flammable, or noxious fluids.

### § 29.610 [Lightning and static electricity protection.]

(a) [The rotorcraft structure must be protected against catastrophic effects from lightning.]

(b) For metallic components, compliance with paragraph (a) of this section may be shown by—

(1) Electrically bonding the components properly to the airframe; or

(2) Designing the components so that a strike will not endanger the rotorcraft.

(c) For nonmetallic components, compliance with paragraph (a) of this section may be shown by—

(1) Designing the components to minimize the effect of a strike; or

(2) Incorporating acceptable means of diverting the resulting electrical current to not endanger the rotorcraft.

[(d) The electric bonding and protection against lightning and static electricity must—

[(1) Minimize the accumulation of electrostatic charge;

[(2) Minimize the risk of electric shock to crew, passengers, and service and maintenance personnel using normal precautions;

[(3) Provide an electrical return path, under both normal and fault conditions, on rotorcraft having grounded electrical systems; and

[(4) Reduce to an acceptable level the effects of lightning and static electricity on the functioning of essential electrical and electronic equipment.]

(Amdt. 29–24, Eff. 12/6/84); [(Amdt. 29–40, Eff. 8/8/96)]

### § 29.611 Inspection provisions.

There must be means to allow close examination of each part that requires—

(a) Recurring inspection;

(b) Adjustment for proper alignment and functioning; or

(c) Lubrication.

### § 29.613 Material strength properties and design values.

(a) Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis.

(b) Design values must be chosen to minimize the probability of structural failure due to material variability. Except as provided in paragraphs (d) and (e) of this section, compliance with this paragraph must be shown by selecting design values that assure material strength with the following probability—

(1) Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in loss of structural integrity of the component, 99 percent probability with 95 percent confidence; and

(2) For redundant structures, those in which the failure of individual elements would result in applied loads being safely distributed to other load-carrying members, 90 percent probability with 95 percent confidence.

(c) The strength, detail design, and fabrication of the structure must minimize the probability of disastrous fatigue failure, particularly at points of stress concentration;

(d) Design values may be those contained in the following publications (available from the Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120) or other values approved by the Administrator:

(1) MIL—HDBK–5, ''Metallic Materials and Elements for Flight Vehicle Structure''.

(2) MIL—HDBK–17, ''Plastics for Flight Vehicles''.

(3) ANC–18, ''Design of Wood Aircraft Structures''.

(4) MIL—HDBK–23, ''Composite Construction for Flight Vehicles''.

(e) Other design values may be used if a selection of the material is made in which a specimen of each individual item is tested before use and it is determined that the actual strength properties of that particular item will equal or exceed those used in design.

[(Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.619 Special factors.

(a) The special factors prescribed in §§ 29.621 through 29.625 apply to each part of the structure whose strength is—

(1) Uncertain;

(2) Likely to deteriorate in service before normal replacement; or

(3) Subject to appreciable variability due to—

(i) Uncertainties in manufacturing processes; or

(ii) Uncertainties in inspection methods.

(b) For each part of the rotorcraft to which §§ 29.621 through 29.625 apply, the factor of safety prescribed in § 29.303 must be multiplied by a special factor equal to—

(1) The applicable special factors prescribed in §§ 29.621 through 29.625; or

(2) Any other factor great enough to ensure that the probability of the part being understrength because of the uncertainties specified in paragraph (a) of this section is extremely remote.

### § 29.621 Casting factors.

(a) *General.* The factors, tests, and inspections specified in paragraphs (b) and (c) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

(b) *Bearing stresses and surfaces.* The casting factors specified in paragraphs (c) and (d) of this section—

(1) Need not exceed 1.25 with respect to bearing stresses regardless of the method of inspection used; and

(2) Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.

(c) *Critical castings.* For each casting whose failure would preclude continued safe flight and landing of the rotorcraft or result in serious injury to any occupant, the following apply:

(1) Each critical casting must—

(i) Have a casting factor of not less than 1.25; and

(ii) Receive 100 percent inspection by visual, radiographic, and magnetic particle (for ferromagnetic materials) or penetrate (for nonferromagnetic materials) inspection methods or approved equivalent inspection methods.

(2) For each critical casting with a casting factor less than 1.50, three sample castings must be static tested and shown to meet—

(i) The strength requirements of § 29.305 at an ultimate load corresponding to a casting factor of 1.25; and

(ii) The deformation requirements of § 29.305 at a load of 1.15 times the limit load.

(d) *Noncritical castings.* For each casting other than those specified in paragraph (c) of this section, the following apply:

(1) Except as provided in paragraphs (d)(2) and (3) of this section, the casting factors and corresponding inspections must meet the following table:

| *Casting factor* | *Inspection* |
|---|---|
| 2.0 or greater | 100 percent visual. |
| Less than 2.0, greater than 1.5 | 100 percent visual, and magnetic particle (ferromagnetic materials), penetrant (nonferromagnetic materials), or approved equivalent inspection methods. |
| 1.25 through 1.50 | 100 percent visual, and magnetic particle (ferromagnetic materials), penetrant (non ferromagnetic materials), and radiographic or approved equivalent inspection methods. |

(2) The percentage of castings inspected by nonvisual methods may be reduced below that specified in paragraph (d)(1) of this section when an approved quality control procedure is established.

(3) For castings procured to a specification that guarantees the mechanical properties of the material in the casting and provides for demonstration of these properties by test of coupons cut from the castings on a sampling basis—

(i) A casting factor of 1.0 may be used; and

(ii) The castings must be inspected as provided in paragraph (d)(1) of this section for casting factors of "1.25 through 1.50" and tested under paragraph (c)(2) of this section.

### § 29.623 Bearing factors.

(a) Except as provided in paragraph (b) of this section, each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.

(b) No bearing factor need be used on a part for which any larger special factor is prescribed.

### § 29.625 Fitting factors.

For each fitting (part or terminal used to join one structural member to another) the following apply:

(a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1.15 must be applied to each part of—

(1) The fitting;

(2) The means of attachment; and

(3) The bearing on the joined members.

(b) No fitting factor need be used—

(1) For joints made under approved practices and based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood); and

(2) With respect to any bearing surface for which a larger special factor is used.

(c) For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member.

### § 29.629 [Flutter and divergence.]

[Each aerodynamic surface of the rotorcraft must be free from flutter and divergence under each appropriate speed and power condition.]

(Amdt. 29–30, Eff. 4/5/90); [(Amdt. 29–40, Eff. 8/8/96)]

### [§ 29.631 Bird strike.

[The rotorcraft must be designated to ensure capability of continued safe flight and landing (for Category A) or safe landing (for Category B) after impact with a 2.2-lb (1.0 kg) bird when the velocity of the rotorcraft (relative to the bird along the flight path of the rotorcraft) is equal to $V_{NE}$ or $V_H$ (whichever is the lesser) at altitudes up to 8,000 feet. Compliance must be shown by tests or by analysis based on tests carried out on sufficiently representative structures of similar design.]

[(Amdt. 29–40, Eff. 8/8/96)]

## ROTORS

### § 29.653 Pressure venting and drainage of rotor blades.

(a) For each rotor blade—

(1) There must be means for venting the internal pressure of the blade;

(2) Drainage holes must be provided for the blade; and

(3) The blade must be designed to prevent water from becoming trapped in it.

(b) Paragraphs (a)(1) and (2) of this section does not apply to sealed rotor blades capable of withstanding the maximum pressure differentials expected in service.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.659 Mass balance.

(a) The rotor and blades must be mass balanced as necessary to—

(1) Prevent excessive vibration; and

(2) Prevent flutter at any speed up to the maximum forward speed.

(b) The structural integrity of the mass balance installation must be substantiated.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.661 Rotor blade clearance.

There must be enough clearance between the rotor blades and other parts of the structure to prevent the blades from striking any part of the structure during any operating condition.

### § 29.663 Ground resonance prevention means.

(a) The reliability of the means for preventing ground resonance must be shown either by analysis and tests, or reliable service experience, or by showing through analysis or tests that malfunction or failure of a single means will not cause ground resonance.

(b) The probable range of variations, during service, of the damping action of the ground resonance prevention means must be established and must be investigated during the test required by § 29.241.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–30, Eff. 4/5/90)]

## CONTROL SYSTEMS

### § 29.671 General.

(a) Each control and control system must operate with the ease, smoothness, and positiveness appropriate to its function.

(b) Each element of each flight control system must be designed, or distinctively and permanently marked, to minimize the probability of any incorrect assembly that could result in the malfunction of the system.

(c) A means must be provided to allow full control movement of all primary flight controls prior to flight, or a means must be provided that will allow the pilot to determine that full control authority is available prior to flight.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.672 Stability augmentation, automatic, and power-operated systems.

If the functioning of stability augmentation or other automatic or power-operated system is necessary to show compliance with the flight characteristics requirements of this part, the system must comply with § 29.671 of this part and the following:

(a) A warning which is clearly distinguishable to the pilot under expected flight conditions without requiring the pilot's attention must be provided for any failure in the stability augmentation system or in any other automatic or power-operated system which could result in an unsafe condition if the pilot is unaware of the failure. Warning systems must not activate the control systems.

(b) The design of the stability augmentation system or of any other automatic or power-operated system must allow initial counteraction of failures without requiring exceptional pilot skill or strength, by overriding the failure by moving the flight controls in the normal sense, and by deactivating the failed system.

(c) It must be shown that after any single failure of the stability augmentation system or any other automatic or power-operated system—

(1) The rotorcraft is safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations;

(2) The controllability and maneuverability requirements of this part are met within a practical operational flight envelope (for example, speed, altitude, normal acceleration, and rotorcraft configurations) which is described in the Rotorcraft Flight Manual; and

(3) The trim and stability characteristics are not impaired below a level needed to allow continued safe flight and landing.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.673 Primary flight controls.

Primary flight controls are those used by the pilot for immediate control of pitch, roll, yaw, and vertical motion of the rotorcraft.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.674 Interconnected controls.

Each primary flight control system must provide for safe flight and landing and operate independently after a malfunction, failure, or jam of any auxiliary interconnected control.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.675 Stops.

(a) Each control system must have stops that positively limit the range of motion of the pilot's controls.

(b) Each stop must be located in the system so that the range of travel of its control is not appreciably affected by—

(1) Wear;

(2) Slackness; or

(3) Takeup adjustments.

(c) Each stop must be able to withstand the loads corresponding to the design conditions for the system.

(d) For each main rotor blade—

(1) Stops that are appropriate to the blade design must be provided to limit travel of the blade about its hinge points; and

(2) There must be means to keep the blade from hitting the droop stops during any operation other than starting and stopping the rotor.

[(Amdt. 29–17, Eff. 12/1/78)]

### § 29.679 Control system locks.

If there is a device to lock the control system with the rotorcraft on the ground or water, there must be means to—

(a) Automatically disengage the lock when the pilot operates the controls in a normal manner, or limit the operation of the rotorcraft so as to give unmistakable warning to the pilot before takeoff; and

(b) Prevent the lock from engaging in flight.

### § 29.681 Limit load static tests.

(a) Compliance with the limit load requirements of this part must be shown by tests in which—

(1) The direction of the test loads produces the most severe loading in the control system; and

(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included;

(b) Compliance must be shown (by analyses or individual load tests) with the special factor requirements for control system joints subject to angular motion.

### § 29.683 Operation tests.

It must be shown by operation tests that, when the controls are operated from the pilot compartment with the control system loaded to correspond with loads specified for the system, the system is free from—

(a) Jamming;

(b) Excessive friction; and

(c) Excessive deflection.

### § 29.685 Control system details.

(a) Each detail of each control system must be designed to prevent jamming, chafing, and interference from cargo, passengers, loose objects, or the freezing of moisture.

(b) There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam the system.

(c) There must be means to prevent the slapping of cables or tubes against other parts.

(d) Cable systems must be designed as follows:

(1) Cables, cable fittings, turnbuckles, splices, and pulleys must be of an acceptable kind.

(2) The design of cable systems must prevent any hazardous change in cable tension throughout the range of travel under any operating conditions and temperature variations.

(3) No cable smaller than one-eighth inch diameter may be used in any primary control system.

(4) Pulley kinds and sizes must correspond to the cables with which they are used. The pulley-cable combinations and strength values specified in MIL–HDBK–5 must be used unless they are inapplicable.

(5) Pulleys must have close fitting guards to prevent the cables from being displaced or fouled.

(6) Pulleys must lie close enough to the plane passing through the cable to prevent the cable from rubbing against the pulley flange.

(7) No fairlead may cause a change in cable direction of more than 3°.

(8) No clevis pin subject to load or motion and retained only by cotter pins may be used in the control system.

(9) Turnbuckles attached to parts having angular motion must be installed to prevent binding throughout the range of travel.

(10) There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle.

(e) Control system joints subject to angular motion must incorporate the following special factors with respect to the ultimate bearing strength of the softest material used as a bearing:

(1) 3.33 for push-pull systems other than ball and roller bearing systems.

(2) 2.0 for cable systems.

(f) For control system joints, the manufacturer's static, non-Brinell rating of ball and roller bearings may not be exceeded.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.687 Spring devices.

(a) Each control system spring device whose failure could cause flutter or other unsafe characteristics must be reliable.

(b) Compliance with paragraph (a) of this section must be shown by tests simulating service conditions.

### § 29.691 Autorotation control mechanism.

Each main rotor blade pitch control mechanism must allow rapid entry into autorotation after power failure.

### § 29.695 Power boost and power-operated control system.

(a) If a power boost or power-operated control system is used, an alternate system must be immediately available that allows continued safe flight and landing in the event of—

(1) Any single failure in the power portion of the system; or

(2) The failure of all engines.

(b) Each alternate system may be a duplicate power portion or a manually operated mechanical system. The power portion includes the power source (such as hydraulic pumps), and such items as valves, lines, and actuators.

(c) The failure of mechanical parts (such as piston rods and links), and the jamming of power cylinders, must be considered unless they are extremely improbable.

## LANDING GEAR

### § 29.723 Shock absorption tests.

The landing inertia load factor and the reserve energy absorption capacity of the landing gear must be substantiated by the tests prescribed in §§ 29.725 and 29.727, respectively. These tests must be conducted on the complete rotorcraft or on units consisting of wheel, tire, and shock absorber in their proper relation.

### § 29.725 Limit drop test.

The limit drop test must be conducted as follows:

(a) The drop height must be at least 8 inches.

(b) If considered, the rotor lift specified in § 29.473(a) must be introduced into the drop test by appropriate energy absorbing devices or by the use of an effective mass.

(c) Each landing gear unit must be tested in the attitude simulating the landing condition that is most critical from the standpoint of the energy to be absorbed by it.

(d) When an effective mass is used in showing compliance with paragraph (b) of this section, the following formulae may be used instead of more rational computations.

$$W_e=W\left[\frac{h+(1-L)d}{h+d}\right]\text{; and } n=n_j\frac{W_e}{W}+L$$

where—

$W_e$=the effective weight to be used in the drop test (lbs).

$W=W_M$ for main gear units (lbs.), equal to the static reaction on the particular unit with the rotorcraft in the most critical attitude. A rational method may be used in computing a main gear static reaction, taking into consideration the moment arm between the main wheel reaction and the rotorcraft center of gravity.

$W=W_N$ for nose gear units (lbs.), equal to the vertical component of the static reaction that would exist at the nose wheel, assuming that the mass of the rotorcraft acts at the center of gravity and exerts a force of 1.0g downward and 0.25g forward.

$W=W_T$ for tailwheel units (lbs.) equal to whichever of the following is critical—

(1) The static weight on the tailwheel with the rotorcraft resting on all wheels; or

(2) The vertical component of the ground reaction that would occur at the tailwheel assuming that the mass of the rotorcraft acts at the center of gravity and exerts a force of 1g downward

with the rotorcraft in the maximum nose-up attitude considered in the nose-up landing conditions.

$h$=specified free drop height (inches).

$L$=ratio of assumed rotor lift to the rotorcraft weight.

$d$=deflection under impact of the tire (at the proper inflation pressure) plus the vertical component of the axle travel (inches) relative to the drop mass.

$n$=limit inertia load factor.

$n_j$=the load factor developed, during impact, on the mass used in the drop test (i.e., the acceleration $dv/dt$ *in g's* recorded in the drop test plus 1.0).

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.727 Reserve energy absorption drop test.

The reserve energy absorption drop test must be conducted as follows:

(a) The drop height must be 1.5 times that specified in § 29.725(a).

(b) Rotor lift, where considered in a manner similar to that prescribed in § 29.725(b), may not exceed 1.5 times the lift allowed under that paragraph.

(c) The landing gear must withstand this test without collapsing. Collapse of the landing gear occurs when a member of the nose, tail, or main gear will not support the rotorcraft in the proper attitude or allows the rotorcraft structure, other than landing gear and external accessories, to impact the landing surface.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.729 Retracting mechanism.

For rotorcraft with retractable landing gear, the following apply:

(a) *Loads.* The landing gear, retracting mechanism, wheel well doors, and supporting structure must be designed for—

(1) The loads occurring in any maneuvering condition with the gear retracted;

(2) The combined friction, inertia, and air loads occurring during retraction and extension at any airspeed up to the design maximum landing gear operating speed; and

(3) The flight loads, including those in yawed flight, occurring with the gear extended at any airspeed up to the design maximum landing gear extended speed.

(b) *Landing gear lock.* A positive means must be provided to keep the gear extended.

(c) *Emergency operation.* When other than manual power is used to operate the gear, emergency means must be provided for extending the gear in the event of—

(1) Any reasonably probable failure in the normal retraction system; or

(2) The failure of any single source of hydraulic, electric, or equivalent energy.

(d) *Operation tests.* The proper functioning of the retracting mechanism must be shown by operation tests.

(e) *Position indicator.* There must be means to indicate to the pilot when the gear is secured in the extreme positions.

(f) *Control.* The location and operation of the retraction control must meet the requirements of §§ 29.777 and 29.779.

(g) *Landing gear warning.* An aural or equally effective landing gear warning device must be provided that functions continuously when the rotorcraft is in a normal landing mode and the landing gear is not fully extended and locked. A manual shutoff capability must be provided for the warning device and the warning system must automatically reset when the rotorcraft is no longer in the landing mode.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.731 Wheels.

(a) Each landing gear wheel must be approved.

(b) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with—

(1) Maximum weight; and

(2) Critical center of gravity.

(c) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the applicable ground load requirements of this part.

### § 29.733 Tires.

Each landing gear wheel must have a tire—

(a) That is a proper fit on the rim of the wheel; and

(b) Of a rating that is not exceeded under—

(1) The design maximum weight;

(2) A load on each main wheel tire equal to the static ground reaction corresponding to the critical center of gravity; and

(3) A load on nose wheel tires (to be compared with the dynamic rating established for those tires) equal to the reaction obtained at the nose wheel, assuming that the mass of the rotorcraft acts as the most critical center of gravity and exerts a force of 1.0g. downward and 0.25g. forward, the reactions being distributed to the nose and main wheels according to the principles of statics with the drag reaction at the ground applied only at wheels with brakes.

(c) Each tire installed on a retractable landing gear system must, at the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tire and any part of the structure or systems.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.735 Brakes.

For rotorcraft with wheel-type landing gear, a braking device must be installed that is—

(a) Controllable by the pilot;

(b) Usable during power-off landings; and

(c) Adequate to—

(1) Counteract any normal unbalanced torque when starting or stopping the rotor; and

(2) Hold the rotorcraft parked on a 10 degree slope on a dry, smooth pavement.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.737 Skis.

(a) The maximum limit load rating of each ski must equal or exceed the maximum limit load determined under the applicable ground load requirements of this part.

(b) There must be a stabilizing means to maintain the ski in an appropriate position during flight. This means must have enough strength to withstand the maximum aerodynamic and inertia loads on the ski.

## FLOATS AND HULLS

### § 29.751 Main float buoyancy.

(a) For main floats, the buoyancy necessary to support the maximum weight of the rotorcraft in fresh water must be exceeded by—

(1) 50 percent, for single floats; and

(2) 60 percent, for multiple floats.

(b) Each main float must have enough watertight compartments so that, with any single main float compartment flooded, the mainfloats will provide a margin of positive stability great enough to minimize the probability of capsizing.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.753 Main float design.

(a) *Bag floats.* Each bag float must be designed to withstand—

(1) The maximum pressure differential that might be developed at the maximum altitude for which certification with the float is requested; and

(2) The vertical loads prescribed in § 29.521(a), distributed along the length of the bag over three-quarters of its projected area.

(b) *Rigid floats.* Each rigid float must be able to withstand the vertical, horizontal and side loads prescribed in § 29.521. An appropriate load distribution under critical conditions must be used.

### § 29.755 Hull buoyancy.

*Water-based and amphibian rotorcraft.* The hull and auxiliary floats, if used, must have enough watertight compartments so that, with any single compartment of the hull or auxiliary floats flooded, the buoyancy of the hull and auxiliary floats, and wheel tires if used, provides a margin of positive water stability great enough to minimize the probability of capsizing the rotorcraft for the worst combination of wave heights and surface winds for which approval is desired.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.757 Hull and auxiliary float strength.

The hull, and auxiliary floats if used, must withstand the water loads prescribed by § 29.519 with a rational and conservative distribution of local and distributed water pressures over the hull and float bottom.

[(Amdt. 29–3, Eff. 2/25/68)]

## PERSONNEL AND CARGO ACCOMMODATIONS

### § 29.771 Pilot compartment.

For each pilot compartment—

(a) The compartment and its equipment must allow each pilot to perform his duties without unreasonable concentration or fatigue;

(b) If there is provision for a second pilot, the rotorcraft must be controllable with equal safety from either pilot position. Flight and powerplant controls must be designed to prevent confusion or inadvertent operation when the rotorcraft is piloted from either position;

(c) The vibration and noise characteristics of cockpit appurtenances may not interfere with safe operation;

(d) Inflight leakage of rain or snow that could distract the crew or harm the structure must be prevented.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.773 Pilot compartment view.

(a) *Nonprecipitation conditions.* For nonprecipitation conditions, the following apply:

(1) Each pilot compartment must be arranged to give the pilots a sufficiently extensive, clear, and undistorted view for safe operation.

(2) Each pilot compartment must be free of glare and reflection that could interfere with the pilot's view. If certification for night operation is requested, this must be shown by night flight tests.

(b) *Precipitation conditions.* For precipitation conditions, the following apply:

(1) Each pilot must have a sufficiently extensive view for safe operation—

(i) In heavy rain at forward speeds up to $V_H$; and

(ii) In the most severe icing condition for which certification is requested.

(2) The first pilot must have a window that—

(i) Is openable under the conditions prescribed in paragraph (b)(1) of this section; and

(ii) Provides the view prescribed in that paragraph.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.775 Windshield and windows.

Windshields and windows must be made of material that will not break into dangerous fragments.

[(Amdt. 29–31, Eff. 10/22/90)]

### § 29.777 Cockpit controls.

Cockpit controls must be—

(a) Located to provide convenient operation and to prevent confusion and inadvertent operation; and

(b) Located and arranged with respect to the pilot's seats so that there is full and unrestricted movement of each control without interference from the cockpit structure or the pilot's clothing when pilots from 5′2″ to 6′0″ in height are seated.

### § 29.779 Motion and effect of cockpit controls.

Cockpit controls must be designed so that they operate in accordance with the following movements and actuation:

(a) Flight controls, including the collective pitch control, must operate with a sense of motion which corresponds to the effect on the rotorcraft.

(b) Twist-grip engine power controls must be designed so that, for lefthand operation, the motion of the pilot's hand is clockwise to increase power when the hand is viewed from the edge containing the index finger. Other engine power controls, excluding the collective control, must operate with a forward motion to increase power.

(c) Normal landing gear controls must operate downward to extend the landing gear.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.783 Doors.

(a) Each closed cabin must have at least one adequate and easily accessible external door.

(b) Each external door must be located, and appropriate operating procedures must be established, to ensure that persons using the door will not be endangered by the rotors, propellers, engine intakes, and exhausts when the operating procedures are used.

(c) There must be means for locking crew and external passenger doors and for preventing their opening in flight inadvertently or as a result of mechanical failure. It must be possible to open external doors from inside and outside the cabin with the rotorcraft on the ground even though persons may be crowded against the door on the inside of the rotorcraft. The means of opening must be simple and obvious and so arranged and marked that it can be readily located and operated.

(d) There must be reasonable provisions to prevent the jamming of any external door in a minor crash as a result of fuselage deformation under the following ultimate inertial forces except for cargo or service doors not suitable for use as an exit in an emergency:

(1) Upward—1.5g.

(2) Forward—4.0g.

(3) Sideward—2.0g.

(4) Downward—4.0g.

(e) There must be means for direct visual inspection of the locking mechanism by crewmembers to determine whether the external doors (including passenger, crew, service, and cargo doors) are fully locked. There must be visual means to signal to appropriate crewmembers when normally used external doors are closed and fully locked.

(f) For outward opening external doors usable for entrance or egress, there must be an auxiliary safety latching device to prevent the door from opening when the primary latching mechanism fails. If the door does not meet the requirements of paragraph (c) of this section with this device in place, suitable operating procedures must be established to prevent the use of the device during takeoff and landing.

(g) If an integral stair is installed in a passenger entry door that is qualified as a passenger emergency exit, the stair must be designed so that under the following conditions the effectiveness of passenger emergency egress will not be impaired:

(1) The door, integral stair, and operating mechanism have been subjected to the inertia forces specified in paragraph (d) of this section, acting separately relative to the surrounding structure.

(2) The rotorcraft is in the normal ground attitude and in each of the attitudes corresponding to collapse of one or more legs, or primary members, as applicable, of the landing gear.

(h) Nonjettisonable doors used as ditching emergency exits must have means to enable them to be secured in the open position and remain secure for emergency egress in sea state conditions prescribed for ditching.

[(Amdt. 29–20, Eff. 10/14/80); (Amdt. 29–29, Eff. 12/13/89); (Amdt. 29–30, Eff. 4/5/90); (Amdt. 29–31, Eff. 10/22/90)]

### § 29.785 Seats, safety belts, and harnesses.

(a) Each seat, safety belt, harness, and adjacent part of the rotorcraft at each station designated for occupancy during takeoff and landing must be free of potentially injurious objects, sharp edges, protuberances, and hard surfaces and must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertial factors specified in § 29.561(b) and dynamic conditions specified in § 29.562.

(b) Each occupant must be protected from serious head injury by a safety belt plus a shoulder harness that will prevent the head from contacting any injurious object, except as provided for in § 29.562(c)(5). A shoulder harness (upper torso restraint), in combination with the safety belt, constitutes a torso restraint system as described in TSO–C114.

(c) Each occupant's seat must have a combined safety belt and shoulder harness with a single-point release. Each pilot's combined safety belt and shoulder harness must allow each pilot when seated with safety belt and shoulder harness fastened to perform all functions necessary for flight operations. There must be a means to secure belt and harness when not in use to prevent interference with the operation of the rotorcraft and with rapid egress in an emergency.

(d) If seat backs do not have a firm handhold, there must be hand grips or rails along each aisle to let the occupants steady themselves while using the aisle in moderately rough air.

(e) Each projecting object that would injure persons seated or moving about in the rotorcraft in normal flight must be padded.

(f) Each seat and its supporting structure must be designed for an occupant weight of at least 170 pounds, considering the maximum load factors, inertial forces, and reactions between the occupant, seat, and safety belt or harness corresponding with the applicable flight and ground-load conditions, including the emergency landing conditions of § 29.561(b). In addition—

(1) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in § 29.397; and

(2) The inertial forces prescribed in § 29.561(b) must be multiplied by a factor of 1.33 in determining the strength of the attachment of—

(i) Each seat to the structure; and

(ii) Each safety belt or harness to the seat or structure.

(g) When the safety belt and shoulder harness are combined, the rated strength of the safety belt and shoulder harness may not be less than that corresponding to the inertial forces specified in § 29.561(b), considering the occupant weight of at least 170 pounds, considering the dimensional characteristics of the restraint system installation, and using a distribution of at least a 60-percent load to the safety belt and at least a 40-percent load to the shoulder harness. If the safety belt is capable of being used without the shoulder harness, the inertial forces specified must be met by the safety belt alone.

(h) When a headrest is used, the headrest and its supporting structure must be designed to resist the inertia forces specified in § 29.561, with a 1.33 fitting factor and a head weight of at least 13 pounds.

(i) Each seating device system includes the device such as the seat, the cushions, the occupant restraint system and attachment devices.

(j) Each seating device system may use design features such as crushing or separation of certain parts of the seat in the design to reduce occupant loads for the emergency landing dynamic conditions of § 29.562; otherwise, the system must remain intact and must not interfere with rapid evacuation of the rotorcraft.

(k) For purposes of this section, a litter is defined as a device designed to carry a nonambulatory person, primarily in a recumbent position, into and on the rotorcraft. Each berth or litter must be designed to withstand the load reaction of an occupant weight of at least 170 pounds when the occupant is subjected to the forward inertial factors specified in § 29.561(b). A berth or litter installed within 15° or less of the longitudinal axis of the rotorcraft must be provided with a padded end-board, cloth diaphragm, or equivalent means that can withstand the forward load reaction. A berth or litter oriented greater than 15° with the longitudinal axis of the rotorcraft must be equipped with appropriate restraints, such as straps or safety belts, to withstand the forward reaction. In addition—

(1) The berth or litter must have a restraint system and must not have corners or other protuberances likely to cause serious injury to a person occupying it during emergency landing conditions; and

(2) The berth or litter attachment and the occupant restraint system attachments to the structure must be designed to withstand the critical loads resulting from flight and ground load conditions and from the conditions prescribed in § 29.561(b).

[(Amdt. 29–24, Eff. 12/6/84); (Amdt. 29–29, Eff. 12/13/89)]

### § 29.787 Cargo and baggage compartments.

(a) Each cargo and baggage compartment must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum load factors corresponding to the specified flight and ground load conditions, except the emergency landing conditions of § 29.561.

(b) There must be means to prevent the contents of any compartment from becoming a hazard by shifting under the loads specified in paragraph (a) of this section.

(c) Under the emergency landing conditions of § 29.561, cargo and baggage compartments must—

(1) Be positioned so that if the contents break loose they are unlikely to cause injury to the occupants or restrict any of the escape facilities provided for use after an emergency landing; or

(2) Have sufficient strength to withstand the conditions specified in § 29.561, including the means of restraint and their attachments required by paragraph (b) of this section. Sufficient strength must be provided for the maximum authorized weight of cargo and baggage at the critical loading distribution.

(d) If cargo compartment lamps are installed, each lamp must be installed so as to prevent contact between lamp bulb and cargo.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–31, Eff. 10/22/90)]

### § 29.801 Ditching.

(a) If certification with ditching provisions is requested, the rotorcraft must meet the requirements of this section and §§ 29.807(d), 29.1411 and 29.1415.

(b) Each practicable design measure, compatible with the general characteristics of the rotorcraft, must be taken to minimize the probability that in an emergency landing on water, the behavior of the rotorcraft would cause immediate injury to the occupants or would make it impossible for them to escape.

(c) The probable behavior of the rotorcraft in a water landing must be investigated by model tests or by comparison with rotorcraft of similar configuration for which the ditching characteristics are known. Scoops, flaps, projections, and any other factors likely to affect the hydrodynamic characteristics of the rotorcraft must be considered.

(d) It must be shown that, under reasonably probable water conditions, the flotation time and trim of the rotorcraft will allow the occupants to leave the rotorcraft and enter the liferafts required by § 29.1415. If compliance with this provision is shown by buoyancy and trim computations, appropriate allowances must be made for probable structural damage and leakage. If the rotorcraft has fuel tanks (with fuel jettisoning provisions) that can reasonably be expected to withstand a ditching without leakage, the jettisonable volume of fuel may be considered as buoyancy volume.

(e) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behavior of the rotorcraft in a water landing (as prescribed in paragraphs (c) and (d) of this section), the external doors and windows must be designed to withstand the probable maximum local pressures.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.803 Emergency evacuation.

(a) Each crew and passenger area must have means for rapid evacuation in a crash landing, with the landing gear (1) extended and (2) retracted, considering the possibility of fire.

(b) Passenger entrance, crew, and service doors may be considered as emergency exits if they meet the requirements of this section and of §§ 29.805 through 29.815.

(c) [Reserved]

(d) Except as provided in paragraph (e) of this section, the following categories of rotorcraft must be tested in accordance with the requirements of appendix D of this part to demonstrate that the maximum seating capacity, including the crewmembers required by the operating rules, can be evacuated from the rotorcraft to the ground within 90 seconds:

(1) Rotorcraft with a seating capacity of more than 44 passengers.

(2) Rotorcraft with all of the following:

(i) Ten or more passengers per passenger exit as determined under § 29.807(b).

(ii) No main aisle, as described in § 29.815, for each row of passenger seats.

(iii) Access to each passenger exit for each passenger by virtue of design features of seats, such as folding or break-over seat backs or folding seats.

(e) A combination of analysis and tests may be used to show that the rotorcraft is capable of being evacuated within 90 seconds under the conditions specified in § 29.803(d) if the Administrator finds that the combination of analysis and test will provide data, with respect to the emergency evacuation capability of the rotorcraft, equivalent to that which would be obtained by actual demonstration.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–30, Eff. 4/5/90)]

## § 29.805 Flight crew emergency exits.

(a) For rotorcraft with passenger emergency exits that are not convenient to the flight crew, there must be flight crew emergency exits, on both sides of the rotorcraft or as a top hatch, in the flight crew area.

(b) Each flight crew emergency exit must be of sufficient size and must be located so as to allow rapid evacuation of the flight crew. This must be shown by test.

(c) Each exit must not be obstructed by water or flotation devices after a ditching. This must be shown by test, demonstration, or analysis.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–30, Eff. 4/5/90)]

## § 29.807 Passenger emergency exits.

(a) *Type.* For the purpose of this part, the types of passenger emergency exit are as follows:

(1) *Type I.* This type must have a rectangular opening of not less than 24 inches wide by 48 inches high, with corner radii not greater than one-third the width of the exit, in the passenger area in the side of the fuselage at floor level and as far away as practicable from areas that might become potential fire hazards in a crash.

(2) *Type II.* This type is the same as Type I, except that the opening must be at least 20 inches wide by 44 inches high.

(3) *Type III.* This type is the same as Type I, except that—

(i) The opening must be at least 20 inches wide by 36 inches high; and

(ii) The exits need not be at floor level.

(4) *Type IV.* This type must have a rectangular opening of not less than 19 inches wide by 26 inches high, with corner radii not greater than one-third the width of the exit, in the side of the fuselage with a step-up inside the rotorcraft of not more than 29 inches.

Openings with dimensions larger than those specified in this section may be used, regardless of shape, if the base of the opening has a flat surface of not less than the specified width.

(b) *Passenger emergency exits; side-of-fuselage.* Emergency exits must be accessible to the passengers and, except as provided in paragraph (d) of this section, must be provided in accordance with the following table:

| Passenger seating capacity | Emergency exits for each side of the fuselage | | | |
|---|---|---|---|---|
| | Type I | Type II | Type III | Type IV |
| 1 through 10 | ........ | ........ | ........ | 1 |
| 11 through 19 | ........ | ........ | 1 or | 2 |
| 20 through 39 | ........ | 1 | ........ | 1 |
| 40 through 59 | 1 | ........ | ........ | 1 |
| 60 through 79 | 1 | ........ | 1 or | 2 |

(c) *Passenger emergency exits; other than side-of-fuselage.* In addition to the requirements of paragraph (b) of this section—

(1) There must be enough openings in the top, bottom, or ends of the fuselage to allow evacuation with the rotorcraft on its side; or

(2) The probability of the rotorcraft coming to rest on its side in a crash landing must be extremely remote.

(d) *Ditching emergency exits for passengers.* If certification with ditching provisions is requested, ditching emergency exits must be provided in accordance with the following requirements and must be proven by test, demonstration, or analysis unless the emergency exits required by paragraph (b) of this section already meet these requirements.

(1) For rotorcraft that have a passenger seating configuration, excluding pilots seats, of nine seats or less, one exit above the waterline in each side of the rotorcraft, meeting at least the dimensions of a Type IV exit.

(2) For rotorcraft that have a passenger seating configuration, excluding pilots seats, of 10 seats or more, one exit above the waterline in a side of the rotorcraft meeting at least the dimensions of a Type III exit, for each unit (or part of a unit) of 35 passenger seats, but no less than two such exits in the passenger cabin, with one on each side of the rotorcraft. However, where it has been shown through analysis, ditching demonstrations, or any other tests found necessary by the Administrator, that the evacuation capability of the rotorcraft during ditching is improved by the use of larger exits, or by other means, the passenger seat to exit ratio may be increased.

(3) Flotation devices, whether stowed or deployed, may not interfere with or obstruct the exits.

(e) *Ramp exits.* One Type I exit only, or one Type II exit only, that is required in the side of the fuselage under paragraph (b) of this section, may be installed instead in the ramp of floor ramp rotorcraft if—

(1) Its installation in the side of the fuselage is impractical; and

(2) Its installation in the ramp meets § 29.813.

(f) *Tests.* The proper functioning of each emergency exit must be shown by test.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.809 Emergency exit arrangement.

(a) Each emergency exit must consist of a movable door or hatch in the external walls of the fuselage and must provide an unobstructed opening to the outside.

(b) Each emergency exit must be openable from the inside and from the outside.

(c) The means of opening each emergency exit must be simple and obvious and may not require exceptional effort.

(d) There must be means for locking each emergency exit and for preventing opening in flight inadvertently or as a result of mechanical failure.

(e) There must be means to minimize the probability of the jamming of any emergency exit in a minor crash landing as a result of fuselage deformation under the ultimate inertial forces in § 29.783(d).

(f) Except as provided in paragraph (h) of this section, each land-based rotorcraft emergency exit must have an approved slide as stated in paragraph (g) of this section, or its equivalent, to assist occupants in descending to the ground from each floor level exit and an approved rope, or its equivalent, for all other exits, if the exit threshold is more that 6 feet above the ground—

(1) With the rotorcraft on the ground and with the landing gear extended;

(2) With one or more legs or part of the landing gear collapsed, broken, or not extended; and

(3) With the rotorcraft resting on its side, if required by § 29.803(d).

(g) The slide for each passenger emergency exit must be a self-supporting slide or equivalent, and must be designed to meet the following requirements:

(1) It must be automatically deployed, and deployment must begin during the interval between the time the exit opening means is actuated from inside the rotorcraft and the time the exit is fully opened. However, each passenger emergency exit which is also a passenger entrance door or a service door must be provided with means to prevent deployment of the slide when the exit is opened from either the inside or the outside under nonemergency conditions for normal use.

(2) It must be automatically erected within 10 seconds after deployment is begun.

(3) It must be of such length after full deployment that the lower end is self-supporting on the ground and provides safe evacuation of occupants to the ground after collapse of one or more legs or part of the landing gear.

(4) It must have the capability, in 25-knot winds directed from the most critical angle, to deploy and, with the assistance of only one person, to remain usable after full deployment to evacuate occupants safely to the ground.

(5) Each slide installation must be qualified by five consecutive deployment and inflation tests conducted (per exit) without failure, and at least three tests of each such five-test series must be conducted using a single representative sample

of the device. The sample devices must be deployed and inflated by the system's primary means after being subjected to the inertia forces specified in § 29.561(b). If any part of the system fails or does not function properly during the required tests, the cause of the failure or malfunction must be corrected by positive means and after that, the full series of five consecutive deployment and inflation tests must be conducted without failure.

(h) For rotorcraft having 30 or fewer passenger seats and having an exit threshold more than 6 feet above the ground, a rope or other assist means may be used in place of the slide specified in paragraph (f) of this section, provided an evacuation demonstration is accomplished as prescribed in § 29.803(d) or (e).

(i) If a rope, with its attachment, is used for compliance with paragraph (f), (g), or (h) of this section, it must—

(1) Withstand a 400-pound static load; and

(2) Attach to the fuselage structure at or above the top of the emergency exit opening, or at another approved location if the stowed rope would reduce the pilot's view in flight.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–29, Eff. 12/13/89); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.811 Emergency exit marking.

(a) Each passenger emergency exit, its means of access, and its means of opening must be conspicuously marked for the guidance of occupants using the exits in daylight or in the dark. Such markings must be designed to remain visible for rotorcraft equipped for overwater flights if the rotorcraft is capsized and the cabin is submerged.

(b) The identity and location of each passenger emergency exit must be recognizable from a distance equal to the width of the cabin.

(c) The location of each passenger emergency exit must be indicated by a sign visible to occupants approaching along the main passenger aisle. There must be a locating sign—

(1) Next to or above the aisle near each floor emergency exit, except that one sign may serve two exits if both exits can be seen readily from that sign; and

(2) On each bulkhead or divider that prevents fore and aft vision along the passenger cabin, to indicate emergency exits beyond and obscured by it, except that if this is not possible the sign may be placed at another appropriate location.

(d) Each passenger emergency exit marking and each locating sign must have white letters 1 inch high on a red background 2 inches high, be self or electrically illuminated, and have a minimum luminescence (brightness) of at least 160 microlamberts. The colors may be reversed if this will increase the emergency illumination of the passenger compartment.

(e) The location of each passenger emergency exit operating handle and instructions for opening must be shown—

(1) For each emergency exit, by a marking on or near the exit that is readable from a distance of 30 inches; and

(2) For each Type I or Type II emergency exit with a locking mechanism released by rotary motion of the handle, by—

(i) A red arrow, with a shaft at least three-fourths inch wide and a head twice the width of the shaft, extending along at least 70° of arc at a radius approximately equal to three-fourths of the handle length; and

(ii) The word "open" in red letters 1 inch high, placed horizontally near the head of the arrow.

(f) Each emergency exit, and its means of opening, must be marked on the outside of the rotorcraft. In addition, the following apply:

(1) There must be a 2-inch colored band outlining each passenger emergency exit, except small rotorcraft with a maximum weight of 12,500 pounds or less may have a 2-inch colored band outlining each exit release lever or device of passenger emergency exits which are normally used doors.

(2) Each outside marking, including the band, must have color contrast to be readily distinguishable from the surrounding fuselage surface. The contrast must be such that, if the reflectance of the darker color is 15 percent or less, the reflectance of the lighter color must be at least 45 percent. "Reflectance" is the ratio of the luminous flux reflected by a body to the luminous flux it receives. When the reflectance of the darker color is greater than 15 percent, at least a 30 percent difference between its reflectance and the reflectance of the lighter color must be provided.

(g) Exits marked as such, though in excess of the required number of exits, must meet the requirements for emergency exits of the particular type. Emergency exits need only be marked with the word "Exit."

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–24, Eff. 12/6/84); (Amdt. 29–30, Eff. 4/5/90); (Amdt. 29–31, Eff. 10/22/90)]

### § 29.812 Emergency lighting.

For transport Category A rotorcraft, the following apply:

(a) A source of light with its power supply independent of the main lighting system must be installed to—

(1) Illuminate each passenger emergency exit marking and locating sign; and

(2) Provide enough general lighting in the passenger cabin so that the average illumination, when measured at 40-inch intervals at seat armrest height on the center line of the main passenger aisle, is at least 0.05 foot-candle.

(b) Exterior emergency lighting must be provided at each emergency exit. The illumination may not be less than 0.05 foot-candle (measured normal to the direction of incident light) for minimum width on the ground surface, with landing gear extended, equal to the width of the emergency exit where an evacuee is likely to make first contact with the ground outside the cabin. The exterior emergency lighting may be provided by either interior or exterior sources with light intensity measurements made with the emergency exits open.

(c) Each light required by paragraph (a) or (b) of this section must be operable manually from the cockpit station and from a point in the passenger compartment that is readily accessible. The cockpit control device must have an "on," "off," and "armed" position so that when turned on at the cockpit or passenger compartment station or when armed at the cockpit station, the emergency lights will either illuminate or remain illuminated upon interruption of the rotorcraft's normal electric power.

(d) Any means required to assist the occupants in descending to the ground must be illuminated so that the erected assist means is visible from the rotorcraft.

(1) The assist means must be provided with an illumination of not less than 0.03 foot-candle (measured normal to the direction of the incident light) at the ground end of the erected assist means where an evacuee using the established escape route would normally make first contact with the ground, with the rotorcraft in each of the attitudes corresponding to the collapse of one or more legs of the landing gear.

(2) If the emergency lighting subsystem illuminating the assist means is independent of the rotorcraft's main emergency lighting system, it—

(i) Must automatically be activated when the assist means is erected;

(ii) Must provide the illumination required by paragraph (d)(1); and

(iii) May not be adversely affected by stowage.

(e) The energy supply to each emergency lighting unit must provide the required level of illumination for at least 10 minutes at the critical ambient conditions after an emergency landing.

(f) If storage batteries are used as the energy supply for the emergency lighting system, they may be recharged from the rotorcraft's main electrical power system provided the charging circuit is designed to preclude inadvertent battery discharge into charging circuit faults.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.813 Emergency exit access.

(a) Each passageway between passenger compartments, and each passageway leading to Type I and Type II emergency exits, must be—

(1) Unobstructed; and

(2) At least 20 inches wide.

(b) For each emergency exit covered by § 29.809(f), there must be enough space adjacent to that exit to allow a crewmember to assist in the evacuation of passengers without reducing the unobstructed width of the passageway below that required for that exit.

(c) There must be access from each aisle to each Type III and Type IV exit, and

(1) For rotorcraft that have a passenger seating configuration, excluding pilot seats, of 20 or more, the projected opening of the exit provided must not be obstructed by seats, berths, or other protrusions (including seatbacks in any position) for a distance from that exit of not less than the width of the narrowest passenger seat installed on the rotorcraft;

(2) For rotorcraft that have a passenger seating configuration, excluding pilot seats, of 19 or less, there may be minor obstructions in the region described in paragraph (c)(1) of this section, if there are compensating factors to maintain the effectiveness of the exit.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.815 Main aisle width.

The main passenger aisle width between seats must equal or exceed the values in the following table:

| Passenger seating capacity | Minimum main passenger aisle width | |
|---|---|---|
| | Less than 25 inches from floor | 25 inches and more from floor |
| | *Inches* | *Inches* |
| 10 or less | 12* | 15 |
| 11 through 19 | 12 | 20 |
| 20 or more | 15 | 20 |

*A narrow width not less than 9 inches may be approved when substantiated by tests found necessary by the Administrator.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.831 Ventilation.

(a) Each passenger and crew compartment must be ventilated, and each crew compartment must have enough fresh air (but not less than 10 cu. ft. per minute per crewmember) to let crewmembers perform their duties without undue discomfort or fatigue.

(b) Crew and passenger compartment air must be free from harmful or hazardous concentrations of gases of vapors.

(c) The concentration of carbon monoxide may not exceed one part in 20,000 parts of air during forward flight. If the concentration exceeds this value under other conditions, there must be suitable operating restrictions.

(d) There must be means to ensure compliance with paragraphs (b) and (c) of this section under any reasonably probable failure of any ventilating, heating, or other system or equipment.

### § 29.833 Heaters.

Each combustion heater must be approved.

## FIRE PROTECTION

### § 29.851 Fire extinguishers.

(a) *Hand fire extinguishers.* For hand fire extinguishers the following apply:

(1) Each hand fire extinguisher must be approved.

(2) The kinds and quantities of each extinguishing agent used must be appropriate to the kinds of fires likely to occur where that agent is used.

(3) Each extinguisher for use in a personnel compartment must be designed to minimize the hazard of toxic gas concentrations.

(b) *Built-in fire extinguishers.* If a built-in fire extinguishing system is required—

(1) The capacity of each system, in relation to the volume of the compartment where used and the ventilation rate, must be adequate for any fire likely to occur in that compartment.

(2) Each system must be installed so that—

(i) No extinguishing agent likely to enter personnel compartments will be present in a quantity that is hazardous to the occupants; and

(ii) No discharge of the extinguisher can cause structural damage.

### § 29.853 Compartment interiors.

For each compartment to be used by the crew or passengers—

(a) The materials (including finishes or decorative surfaces applied to the materials) must meet the following test criteria as applicable:

(1) Interior ceiling panels, interior wall panels, partitions, galley structure, large cabinet walls, structural flooring, and materials used in the construction of stowage compartments (other than underseat stowage compartments and compartments for stowing small items such as magazines and maps) must be self-extinguishing when tested vertically in accordance with the applicable portions of appendix F of part 25 of this chapter, or other approved equivalent methods. The average burn length may not exceed 6 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 3 seconds after falling.

(2) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and non-decorative coated fabrics, leather, trays and galley furnishings, electrical conduit, thermal and acoustical insulation and insulation covering, air ducting joint and edge covering, cargo compartment liners, insulation blankets, cargo cover, and transparencies, molded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing) that are constructed of materials not covered in paragraph (a)(3) of this section, must be self extinguishing when tested vertically in accordance with the applicable portion of appendix F of part 25 of this chapter, or other approved equivalent methods. The average burn length may not exceed 8 inches and the average flame time after removal of the flame source may not exceed

15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 5 seconds after falling.

(3) Acrylic windows and signs, parts constructed in whole or in part of elasto-metric materials, edge lighted instrument assemblies consisting of two or more instruments in a common housing, seat belts, shoulder harnesses, and cargo and baggage tiedown equipment, including containers, bins, pallets, etc., used in passenger or crew compartments, may not have an average burn rate greater than 2.5 inches per minute when tested horizontally in accordance with the applicable portions of appendix F of part 25 of this chapter, or other approved equivalent methods.

(4) Except for electrical wire and cable insulation, and for small parts (such as knobs, handles, rollers, fasteners, clips, grommets, rub strips, pulleys, and small electrical parts) that the Administrator finds would not contribute significantly to the propagation of a fire, materials in items not specified in paragraphs (a)(1), (a)(2), or (a)(3) of this section may not have a burn rate greater than 4 inches per minute when tested horizontally in accordance with the applicable portions of appendix F of part 25 of this chapter, or other approved equivalent methods.

(b) In addition to meeting the requirements of paragraph (a)(2), seat cushions, except those on flight crewmember seats, must meet the test requirements of part II of appendix F of part 25 of this chapter, or equivalent.

(c) If smoking is to be prohibited, there must be a placard so stating, and if smoking is to be allowed—

(1) There must be an adequate number of self-contained removable ashtrays; and

(2) Where the crew compartment is separated from the passenger compartment, there must be at least one illuminated sign (using either letters or symbols) notifying all passengers when smoking is prohibited. Signs which notify when smoking is prohibited must—

(i) When illuminated, be legible to each passenger seated in the passenger cabin under all probable lighting conditions; and

(ii) Be so constructed that the crew can turn the illumination on and off.

(d) Each receptacle for towels, paper, or waste must be at least fire-resistant and must have means for containing possible fires.

(e) There must be a hand fire extinguisher for the flight crewmembers; and

(f) At least the following number of hand fire extinguishers must be conveniently located in passenger compartments:

| *Passenger capacity:* | *Fire extinguishers* |
|---|---|
| 7 through 30 | 1 |
| 31 through 60 | 2 |
| 61 or more | 3 |

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–18, Eff. 3/6/80); (Amdt. 29–23, Eff. 11/26/84)]

### § 29.855 Cargo and baggage compartments.

(a) Each cargo and baggage compartment must be constructed of or lined with materials in accordance with the following:

(1) For accessible and inaccessible compartments not occupied by passengers or crew, the material must be at least fire resistant.

(2) Materials must meet the requirements in § 29.853(a)(1), (a)(2), and (a)(3) for cargo or baggage compartments in which—

(i) The presence of a compartment fire would be easily discovered by a crewmember while at the crewmember's station;

(ii) Each part of the compartment is easily accessible in flight;

(iii) The compartment has a volume of 200 cubic feet or less; and

(iv) Notwithstanding § 29.1439(a), protective breathing equipment is not required.

(b) No compartment may contain any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operation, unless those items are protected so that—

(1) They cannot be damaged by the movement of cargo in the compartment; and

(2) Their breakage or failure will not create a fire hazard.

(c) The design and sealing of inaccessible compartments must be adequate to contain compartment fires until a landing and safe evacuation can be made.

(d) Each cargo and baggage compartment that is not sealed so as to contain cargo compartment fires completely without endangering the safety of a rotorcraft or its occupants must be designed, or must have a device, to ensure detection of fires or smoke by a crewmember while at his station and to prevent the accumulation of harmful quantities of smoke, flame, extinguishing agents, and other noxious gases in any crew or passenger compartment. This must be shown in flight.

(e) For rotorcraft used for the carriage of cargo only, the cabin area may be considered a cargo compartment and, in addition to paragraphs (a) through (d) of this section, the following apply:

(1) There must be means to shut off the ventilating airflow to or within the compartment. Controls for this purpose must be accessible to the flight crew in the crew compartment.

(2) Required crew emergency exits must be accessible under all cargo loading conditions.

(3) Sources of heat within each compartment must be shielded and insulated to prevent igniting the cargo.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–24, Eff. 12/6/84); (Amdt. 29–30, Eff. 4/5/90)]

### § 29.859 Combustion heater fire protection.

(a) *Combustion heater fire zones.* The following combustion heater fire zones must be protected against fire under the applicable provisions of §§ 29.1181 through 29.1191, and 29.1195 through 29.1203:

(1) The region surrounding any heater, if that region contains any flammable fluid system components (including the heater fuel system), that could—

(i) Be damaged by heater malfunctioning; or

(ii) Allow flammable fluids or vapors to reach the heater in case of leakage.

(2) Each part of any ventilating air passage that—

(i) Surrounds the combustion chamber; and

(ii) Would not contain (without damage to other rotorcraft components) any fire that may occur within the passage.

(b) *Ventilating air ducts.* Each ventilating air duct passing through any fire zone must be fireproof. In addition—

(1) Unless isolation is provided by fireproof valves or by equally effective means, the ventilating air duct downstream of each heater must be fireproof for a distance great enough to ensure that any fire originating in the heater can be contained in the duct; and

(2) Each part of any ventilating duct passing through any region having a flammable fluid system must be so constructed or isolated from that system that the malfunctioning of any component of that system cannot introduce flammable fluids or vapors into the ventilating airstream.

(c) *Combustion air ducts.* Each combustion air duct must be fireproof for a distance great enough to prevent damage from backfiring or reverse flame propagation. In addition—

(1) No combustion air duct may communicate with the ventilating airstream unless flames from backfires or reverse burning cannot enter the ventilating airstream under any operating condition, including reverse flow or malfunction of the heater or its associated components; and

(2) No combustion air duct may restrict the prompt relief of any backfire that, if so restricted, could cause heater failure.

(d) *Heater controls; general.* There must be means to prevent the hazardous accumulation of water or ice on or in any heater control component, control system tubing, or safety control.

(e) *Heater safety controls.* For each combustion heater, safety control means must be provided as follows:

(1) Means independent of the components provided for the normal continuous control of air temperature, airflow, and fuel flow must be provided, for each heater, to automatically shut off the ignition and fuel supply of that heater at a point remote from that heater when any of the following occurs:

(i) The heat exchanger temperature exceeds safe limits.

(ii) The ventilating air temperature exceeds safe limits.

(iii) The combustion airflow becomes inadequate for safe operation.

(iv) The ventilating airflow becomes inadequate for safe operation.

(2) The means of complying with paragraph (e)(1) of this section for any individual heater must—

(i) Be independent of components serving any other heater whose heat output is essential for safe operation; and

(ii) Keep the heater off until restarted by the crew.

(3) There must be means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means prescribed in paragraph (e)(1) of this section.

(f) *Air intakes.* Each combustion and ventilating air intake must be where no flammable fluids or vapors can enter the heater system under any operating condition—

(1) During normal operation; or

(2) As a result of the malfunction of any other component.

(g) *Heater exhaust.* Each heater exhaust system must meet the requirements of §§ 29.1121 and 29.1123. In addition—

(1) Each exhaust shroud must be sealed so that no flammable fluids or hazardous quantities of vapors can reach the exhaust systems through joints; and

(2) No exhaust system may restrict the prompt relief of any backfire that, if so restricted, could cause heater failure.

(h) *Heater fuel systems.* Each heater fuel system must meet the powerplant fuel system requirements affecting safe heater operation. Each heater fuel system component in the ventilating airstream must be protected by shrouds so that no leakage from those components can enter the ventilating airstream.

(i) *Drains.* There must be means for safe drainage of any fuel that might accumulate in the combustion chamber or the heat exchanger. In addition—

(1) Each part of any drain that operates at high temperatures must be protected in the same manner as heater exhausts; and

(2) Each drain must be protected against hazardous ice accumulation under any operating condition.

[(Amdt. 29–2, Eff. 6/4/67)]

### § 29.861 Fire protection of structure, controls, and other parts.

Each part of the structure, controls, and the rotor mechanism, and other parts essential to controlled landing and (for category A) flight that would be affected by powerplant fires must be isolated under § 29.1191, or must be—

(a) For category A rotorcraft, fireproof; and

(b) For Category B rotorcraft, fireproof or protected so that they can perform their essential functions for at least 5 minutes under any foreseeable powerplant fire conditions.

[(Amdt. 29–30, Eff. 4/5/90)]

### § 29.863 Flammable fluid fire protection.

(a) In each area where flammable fluids or vapors might escape by leakage of a fluid system, there must be means to minimize the probability of ignition of the fluids and vapors, and the resultant hazards if ignition does occur.

(b) Compliance with paragraph (a) of this section must be shown by analysis or tests, and the following factors must be considered:

(1) Possible sources and paths of fluid leakage, and means of detecting leakage.

(2) Flammability characteristics of fluids, including effects of any combustible or absorbing materials.

(3) Possible ignition sources, including electrical faults, overheating of equipment, and malfunctioning of protective devices.

(4) Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents.

(5) Ability of rotorcraft components that are critical to safety of flight to withstand fire and heat.

(c) If action by the flight crew is required to prevent or counteract a fluid fire (e.g. equipment shutdown or actuation of a fire extinguisher), quick acting means must be provided to alert the crew.

(d) Each area where flammable fluids or vapors might escape by leakage of a fluid system must be identified and defined.

[(Amdt. 29–17, Eff. 12/1/78)]

## EXTERNAL LOAD ATTACHING MEANS

### § 29.865 External load attaching means.

(a) It must be shown by analysis or test, or both, that the rotorcraft external-load attaching means can withstand a limit static load equal to 2.5, or some lower factor approved under §§ 29.337 through 29.341, multiplied by the maximum external load for which authorization is requested. The load is applied in the vertical direction and in any direction making an angle of 30° with the vertical, except for those directions having a forward component. However, the 30° angle may be reduced to a lesser angle if—

(1) An operating limitation is established limiting external load operations to such angles for which compliance with this paragraph has been shown; or

(2) It is shown that the lesser angle can not be exceeded in service.

(b) The external load attaching means for Class B and Class C rotorcraft-load combinations must include a device to enable the pilot to release the external load quickly during flight. This quick-release device, and the means by which it is controlled, must comply with the following:

(1) A control for the quick-release device must be installed on one of the pilot's primary controls and must be designed and located so that it may be operated by the pilot without hazardously limiting his ability to control the rotorcraft during an emergency situation.

(2) In addition, a manual mechanical control for the quick-release device, readily accessible either to the pilot or to another crew member, must be provided.

(3) The quick-release device must function properly with all external loads up to and including the maximum external load for which authorization is requested.

(c) A placard or marking must be installed next to the external-load attaching means stating the maximum authorized external load as demonstrated under § 29.25 and this section.

(d) The fatigue evaluation of § 29.571(a) does not apply to this section except for a failure of the cargo attaching means that results in a hazard to the rotorcraft.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–30, Eff. 4/5/90)]

## MISCELLANEOUS

### § 29.871 Leveling marks.

There must be reference marks for leveling the rotorcraft on the ground.

### § 29.873 Ballast provisions.

Ballast provisions must be designed and constructed to prevent inadvertent shifting of ballast in flight.

### § 29.877 [Reserved.]

# Subpart E—Powerplant

## GENERAL

### § 29.901 Installation.

(a) For the purpose of this part, the powerplant installation includes each part of the rotorcraft (other than the main and auxiliary rotor structures) that—

(1) Is necessary for propulsion;

(2) Affects the control of the major propulsive units; or

(3) Affects the safety of the major propulsive units between normal inspections or overhauls.

(b) For each powerplant installation—

(1) The installation must comply with—

(i) The installation instructions provided under § 33.5 of this chapter; and

(ii) The applicable provisions of this subpart.

(2) Each component of the installation must be constructed, arranged, and installed to ensure its continued safe operation between normal inspections or overhauls for the range of temperature and altitude for which approval is requested.

(3) Accessibility must be provided to allow any inspection and maintenance necessary for continued airworthiness;

(4) Electrical interconnections must be provided to prevent differences of potential between major components of the installation and the rest of the rotorcraft; and

(5) Axial and radial expansion of turbine engines may not affect the safety of the installation.

(6) Design precautions must be taken to minimize the possibility of incorrect assembly of components and equipment essential to safe operation of the rotorcraft, except where operation with the incorrect assembly can be shown to be extremely improbable.

(c) [For each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the rotorcraft except that the failure of structural elements need not be considered if the probability of any such failure is extremely remote.]

(d) Each auxiliary power unit installation must meet the applicable provisions of this subpart.

(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–36, Eff. 1/31/96)]

### § 29.903 Engines.

(a) *Engine type certification.* Each engine must have an approved type certificate. Reciprocating engines for use in helicopters must be qualified in accordance with § 33.49(d) of this chapter or be otherwise approved for the intended usage.

(b) *Category A: Engine isolation.* For each category A rotorcraft, the powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or the failure of any system that can affect any engine, will not—

(1) Prevent the continued safe operation of the remaining engines; or

(2) Require immediate action, other than normal pilot action with primary flight controls, by any crewmember to maintain safe operation.

(c) *Category A: Control of engine rotation.* For each category A rotorcraft, there must be a means for stopping the rotation of any engine individually in flight, except that, for turbine engine installations, the means for stopping the engine need be provided only where necessary for safety. In addition—

(1) Each component of the engine stopping system that is located on the engine side of the firewall, and that might be exposed to fire, must be at least fire resistant; or

(2) Duplicate means must be available for stopping the engine and the controls must be where all are not likely to be damaged at the same time in case of fire.

(d) [*Turbine engine installation.* For turbine engine installations—

[(1) Design precautions must be taken to minimize the hazards to the rotorcraft in the event of an engine rotor failure; and

[(2) The powerplant systems associated with engine control devices, systems, and instrumentation must be designed to give reasonable assurance that those engine operating limitations that adversely affect engine rotor structural integrity will not be exceeded in service.]

(e) *Restart capability:*

(1) A means to restart any engine in flight must be provided.

(2) Except for the in-flight shutdown of all engines, engine restart capability must be demonstrated throughout a flight envelope for the rotorcraft.

(3) Following the in-flight shutdown of all engines, in-flight engine restart capability must be provided.

(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88); (Amdt. 29–31, Eff. 10/22/90); [(Amdt. 29–36, Eff. 1/31/96)]

### § 29.907 Engine vibration.

(a) Each engine must be installed to prevent the harmful vibration of any part of the engine or rotorcraft.

(b) The addition of the rotor and the rotor drive system to the engine may not subject the principal rotating parts of the engine to excessive vibration stresses. This must be shown by a vibration investigation.

### § 29.908 Cooling fans.

For cooling fans that are a part of a powerplant installation the following apply:

(a) *Category A.* For cooling fans installed in Category A rotorcraft, it must be shown that a fan blade failure will not prevent continued safe flight either because of damage caused by the failed blade or loss of cooling air.

(b) *Category B.* For cooling fans installed in category B rotorcraft, there must be means to protect the rotorcraft and allow a safe landing if a fan blade fails. It must be shown that—

(1) The fan blade would be contained in the case of a failure;

(2) Each fan is located so that a fan blade failure will not jeopardize safety; or

(3) Each fan blade can withstand an ultimate load of 1.5 times the centrifugal force expected in service, limited by either—

(i) The highest rotational speeds achievable under uncontrolled conditions; or

(ii) An overspeed limiting device.

(c) *Fatigue evaluation.* Unless a fatigue evaluation under § 29.571 is conducted, it must be shown that cooling fan blades are not operating at resonant conditions within the operating limits of the rotorcraft.

[(Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

## ROTOR DRIVE SYSTEM

### § 29.917 Design.

(a) *General.* The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gear boxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the rotor drive system.

[(b) *Design assessment.* A design assessment must be performed to ensure that the rotor drive system functions safely over the full range of conditions for which certification is sought. The design assessment must include a detailed failure analysis to identify all failures that will prevent continued safe flight or safe landing and must identify the means to minimize the likelihood of their occurrence.]

([c]) *Arrangement.* Rotor drive systems must be arranged as follows:

(1) Each rotor drive system of multi-engine rotorcraft must be arranged so that each rotor necessary for operation and control will continue to be driven by the remaining engines if any engine fails.

(2) For single-engine rotorcraft, each rotor drive system must be so arranged that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of the engine from the main and auxiliary rotors.

(3) Each rotor drive system must incorporate a unit for each engine to automatically disengage that engine from the main and auxiliary rotors if that engine fails.

(4) If a torque limiting device is used in the rotor drive system, it must be located so as to allow continued control of the rotorcraft when the device is operating.

(5) If the rotors must be phased for intermeshing, each system must provide constant and positive phase relationship under any operating condition.

(6) If a rotor dephasing device is incorporated, there must be means to keep the rotors locked in proper phase before operation.

(Amdt. 29–12, Eff. 2/1/77); [(Amdt. 29–40, Eff. 8/8/96)]

### § 29.921 Rotor brake.

If there is a means to control the rotation of the rotor drive system independently of the engine, any limitations on the use of that means must be specified, and the control for that means must be guarded to prevent inadvertent operation.

### § 29.923 Rotor drive system and control mechanism tests.

(a) *Endurance tests, general.* Each rotor drive system and rotor control mechanism must be tested, as prescribed in paragraphs (b) through (n) of this section, for at least 200 hours plus the time required to meet the requirements of paragraphs (b)(2), (b)(3), and (k) of this section. These tests must be conducted as follows:

(1) Ten-hour test cycles must be used, except that the test cycle must be extended to include the OEI test of paragraphs (b)(2) and (k) of this section, if OEI ratings are requested.

(2) The tests must be conducted on the rotorcraft.

(3) The test torque and rotational speed must be—

(i) Determined by the powerplant limitations; and

(ii) Absorbed by the rotors to be approved for the rotorcraft.

(b) *Endurance tests, takeoff run.* The takeoff run must be conducted as follows:

(1) Except as prescribed in paragraphs (b)(2) and (b)(3) of this section, the takeoff torque run must consist of 1 hour of alternate runs of 5 minutes at takeoff torque and the maximum speed for use with takeoff torque, and 5 minutes at as low an engine idle speed as practicable. The engine must be declutched from the rotor drive system, and the rotor brake, if furnished and so intended, must be applied during the first minute of the idle run. During the remaining 4 minutes of the idle run, the clutch must be engaged so that the engine drives the rotors at the minimum practical r.p.m. The engine and the rotor drive system must be accelerated at the maximum rate. When declutching the engine, it must be decelerated rapidly enough to allow the operation of the overrunning clutch.

(2) For helicopters for which the use of a 2½-minute OEI rating is requested, the takeoff run must be conducted as prescribed in paragraph (b)(1) of this section, except for the third and sixth runs for which the takeoff torque and the maximum speed for use with takeoff torque are prescribed in that paragraph. For these runs, the following apply:

(i) Each run must consist of at least one period of 2½ minutes with takeoff torque and the maximum speed for use with takeoff torque on all engines.

(ii) Each run must consist of at least one period, for each engine in sequence, during which that engine simulates a power failure and the remaining engines are run at the 2½-minutes OEI torque and the maximum speed for use with 2½-minute OEI torque for 2½ minutes.

(3) For multiengine, turbine-powered rotorcraft for which the use of 30-second/2-minute OEI power is requested, the takeoff run must be conducted as prescribed in paragraph (b)(1) of this section except for the following:

(i) [Immediately following any one 5-minute power-on run required by paragraph (b)(1) of this section, simulate a failure for each power source in turn, and apply the maximum torque and the maximum speed for use with 30-second OEI power to the remaining affected drive system power inputs for not less than 30 seconds. Each application of 30-second OEI power must be followed by two applications of the maximum torque and the maximum speed for use with the 2 minute OEI power for not less than 2 minutes each; the second application must follow a period at stabilized continuous or 30 minute OEI power (whichever is requested by the applicant). At least one run sequence must be conducted from a simulated ''flight idle'' condition. When conducted on a bench test, the test sequence must be conducted following stabilization at takeoff power.]

(ii) For the purpose of this paragraph, an affected power input includes all parts of the rotor drive system which can be adversely affected by the application of higher or asymmetric torque and speed prescribed by the test.

(iii) This test may be conducted on a representative bench test facility when engine limitations either preclude repeated use of this power or would result in premature engine removals during the test. The loads, the vibration frequency, and the methods of application to the affected rotor drive system components must be representative of rotorcraft conditions. Test components must be those used to show compliance with the remainder of this section.

(c) *Endurance tests, maximum continuous run.* Three hours of continuous operation at maximum continuous torque and the maximum speed for use with maximum continuous torque must be conducted as follows:

(1) The main rotor controls must be operated at a minimum of 15 times each hour through the main rotor pitch positions of maximum vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component, and maximum right thrust component, except that the control movements need not produce loads or blade flapping motion exceeding the maximum loads of motions encountered in flight.

(2) The directional controls must be operated at a minimum of 15 times each hour through the control extremes of maximum right turning torque, neutral torque as required by the power applied to the main rotor, and maximum left turning torque.

(3) Each maximum control position must be held for at least 10 seconds, and the rate of change of control position must be at least as rapid as that for normal operation.

(d) *Endurance tests; 90 percent of maximum continuous run.* One hour of continuous operation at 90 percent of maximum continuous torque and the maximum speed for use with 90 percent of maximum continuous torque must be conducted.

(e) *Endurance tests; 80 percent of maximum continuous run.* One hour of continuous operation at 80 percent of maximum continuous torque and the minimum speed for use with 80 percent of maximum continuous torque must be conducted.

(f) *Endurance tests; 60 percent of maximum continuous run.* Two hours or, for helicopters for which the use of either 30-minute OEI power or continuous OEI power is requested, 1 hour of continuous operation at 60 percent of maximum continuous torque and the minimum speed for use with 60 percent of maximum continuous torque must be conducted.

(g) *Endurance tests; engine malfunctioning run.* It must be determined whether malfunctioning of components, such as the engine fuel or ignition systems, or whether unequal engine power can cause dynamic conditions detrimental to the drive system. If so, a suitable number of hours of operation must be accomplished under those conditions, 1 hour of which must be included in each cycle, and the remaining hours of which must be accomplished at the end of the 20 cycles. If no detrimental condition results, an additional hour of operation in compliance with paragraph (b) of this section must be conducted in accordance with the run schedule of paragraph (b)(1) of this section without consideration of paragraph (b)(2) of this section.

(h) *Endurance tests; overspeed run.* One hour of continuous operation must be conducted at maximum continuous torque and the maximum power-on overspeed expected in service, assuming that speed and torque limiting devices, if any, function properly.

(i) *Endurance tests; rotor control positions.* When the rotor controls are not being cycled during the tie-down tests, the rotor must be operated, using the procedures prescribed in paragraph (c) of this section, to produce each of the maximum thrust positions for the following percentages of test time (except that the control positions need not produce loads or blade flapping motion exceeding the maximum loads or motions encountered in flight):

(1) For full vertical thrust, 20 percent.

(2) For the forward thrust component, 50 percent.

(3) For the right thrust component, 10 percent.

(4) For the left thrust component, 10 percent.

(5) For the aft thrust component, 10 percent.

(j) *Endurance tests, clutch and brake engagements.* A total of at least 400 clutch and brake engagements, including the engagements of paragraph (b) of this section, must be made during the takeoff torque runs and, if necessary, at each change of torque and speed throughout the test. In each clutch engagement, the shaft on the driven side of the clutch must be accelerated from rest. The clutch engagements must be accomplished at the speed and by the method prescribed by the applicant. During deceleration after each clutch engagement, the engines must be stopped rapidly enough to allow the engines to be automatically disengaged from the rotors and rotor drives. If a rotor brake is installed for stopping the rotor, the clutch, during brake engagements, must be disengaged above 40 percent of maximum continuous rotor speed and the rotors allowed to decelerate to 40 percent of maximum continuous rotor speed, at which time the rotor brake must be applied. If the clutch design does not allow stopping the rotors with the engine running, or if no clutch is provided, the engine must be stopped before each application of the rotor brake, and then immediately be started after the rotors stop.

(k) *Endurance tests, OEI power run.*

(1) *30-minute OEI power run.* For rotorcraft for which the use of 30-minute OEI power is requested, a run at 30-minute OEI torque and the maximum speed for use with 30-minute OEI torque must be conducted as follows: For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for a 30-minute period.

(2) *Continuous OEI power run.* For rotorcraft for which the use of continuous OEI power is requested, a run at continuous OEI torque and the maximum speed for use with continuous OEI torque must be conducted as follows: For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for 1 hour.

(3) The number of periods prescribed in paragraph (k)(1) or (k)(2) of this section may not be less than the number of engines, nor may it be less than two.

(l) [Reserved]

(m) Any components that are affected by maneuvering and gust loads must be investigated for the same flight conditions as are the main rotors, and their service lives must be determined by fatigue tests or by other acceptable methods. In addition, a level of safety equal to that of the main rotors must be provided for—

(1) Each component in the rotor drive system whose failure would cause an uncontrolled landing;

(2) Each component essential to the phasing of rotors on multirotor rotorcraft, or that furnishes a driving link for the essential control of rotors in autorotation; and

(3) Each component common to two or more engines on multiengine rotorcraft.

(n) *Special tests.* Each rotor drive system designed to operate at two or more gear ratios must be subjected to special testing for durations necessary to substantiate the safety of the rotor drive system.

(o) Each part tested as prescribed in this section must be in a serviceable condition at the end of the tests. No intervening disassembly which might affect test results may be conducted.

(p) *Endurance tests; operating lubricants.* To be approved for use in rotor drive and control systems, lubricants must meet the specifications of lubricants used during the tests prescribed by this section. Additional or alternate lubricants may be qualified by equivalent testing or by comparative analysis of lubricant specifications and rotor drive and control system characteristics. In addition—

(1) At least three 10-hour cycles required by this section must be conducted with transmission and gearbox lubricant temperatures, at the location prescribed for measurement, not lower than the maximum operating temperature for which approval is requested;

(2) For pressure lubricated systems, at least three 10-hour cycles required by this section must be conducted with the lubricant pressure, at the location prescribed for measurement, not higher than the minimum operating pressure for which approval is requested; and

(3) The test conditions of paragraphs (p)(1) and (p)(2) of this section must be applied simultaneously and must be extended to include operation at any one-engine-inoperative rating for which approval is requested.

(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–26, Eff. 10/3/88); (Amdt. 29–31, Eff. 10/22/90); (Amdt. 29–34, Eff. 10/17/94); [(Amdt. 29–40, Eff. 8/8/96)]

## § 29.927 Additional tests.

(a) Any additional dynamic, endurance, and operational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(b) If turbine engine torque output to the transmission can exceed the highest engine or transmission torque limit, and that output is not directly controlled by the pilot under normal operating conditions (such as where the primary engine power control is accomplished through the flight control), the following test must be made:

(1) Under conditions associated with all engines operating, make 200 applications, for 10 seconds each, of torque that is at least equal to the lesser of—

(i) The maximum torque used in meeting § 29.923 plus 10 percent; or

(ii) The maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly.

(2) For multiengine rotorcraft under conditions associated with each engine, in turn, becoming inoperative, apply to the remaining transmission torque inputs the maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly. Each transmission input must be tested at this maximum torque for at least fifteen minutes.

(c) *Lubrication system failure.* For lubrication systems required for proper operation of rotor drive systems, the following apply:

(1) *Category A.* Unless such failures are extremely remote, it must be shown by test that any failure which results in loss of lubricant in any normal use lubrication system will not prevent continued safe operation, although not necessarily without damage, at a torque and rotational speed prescribed by the applicant for continued flight, for at least 30 minutes after perception by the flightcrew of the lubrication system failure or loss of lubricant.

(2) *Category B.* The requirements of Category A apply except that the rotor drive system need only be capable of operating under autorotative conditions for a least 15 minutes.

(d) *Overspeed test.* The rotor drive system must be subjected to 50 overspeed runs, each 30 ± 3 seconds in duration, at not less than either the higher of the rotational speed to be expected from an engine control device failure or 105 percent of the maximum rotational speed, including transients, to be expected in service. If speed and torque limiting devices are installed, are independent of the normal engine control, and are shown to be reliable, their rotational speed limits need not be exceeded. These runs must be conducted as follows:

(1) Overspeed runs must be alternated with stabilizing runs of from 1 to 5 minutes duration each at 60 to 80 percent of maximum continuous speed.

(2) Acceleration and deceleration must be accomplished in a period not longer than 10 seconds (except where maximum engine acceleration rate will require more than 10 seconds), and the time for changing speeds may not be deducted from the specified time for the overspeed runs.

(3) Overspeed runs must be made with the rotors in the flattest pitch for smooth operation.

(e) The tests prescribed in paragraphs (b) and (d) of this section must be conducted on the rotorcraft and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.

(f) Each test prescribed by this section must be conducted without intervening disassembly and, except for the lubrication system failure test required by paragraph (c) of this section, each part tested must be in a serviceable condition at the conclusion of the test.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–17, Eff. 12/1/78; (Amdt. 29–26, Eff. 10/3/88)]

## § 29.931 Shafting critical speed.

(a) The critical speeds of any shafting must be determined by demonstration except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(b) If any critical speed lies within, or close to, the operating ranges for idling, power-on, and autorotative conditions, the stresses occurring at that speed must be within safe limits. This must be shown by tests.

(c) If analytical methods are used and show that no critical speed lies within the permissible operating ranges, the margins between the calculated critical speeds and the limits of the allowable operating ranges must be adequate to allow for possible variations between the computed and actual values.

[(Amdt. 29–12, Eff. 2/1/77)]

## § 29.935 Shafting joints.

Each universal joint, slip joint, and other shafting joints whose lubrication is necessary for operation must have provision for lubrication.

## § 29.939 Turbine engine operating characteristics.

(a) Turbine engine operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operation within the range of operating limitations of the rotorcraft and of the engine.

(b) The turbine engine air inlet system may not, as a result of airflow distortion during normal operation, cause vibration harmful to the engine.

(c) For governor-controlled engines, it must be shown that there exists no hazardous torsional instability of the drive system associated with critical combinations of power, rotational speed, and control displacement.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–12, Eff. 2/1/77)]

## FUEL SYSTEM

### § 29.951 General.

(a) Each fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine and auxiliary power unit functioning under any likely operating conditions, including the maneuvers for which certification is requested and during which the engine or auxiliary power unit is permitted to be in operation.

(b) Each fuel system must be arranged so that—

(1) No engine or fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

(c) Each fuel system for a turbine engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 80° F. and having 0.75 cc. of free water per gallon added and cooled to the most critical condition for icing likely to be encountered in operation.

[(Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–12, Eff. 2/1/77)]

### [§ 29.952 Fuel system crash resistance.

[Unless other means acceptable to the Administrator are employed to minimize the hazard of fuel fires to occupants following an otherwise survivable impact (crash landing), the fuel systems must incorporate the design features of this section. These systems must be shown to be capable of sustaining the static and dynamic deceleration loads of this section, considered as ultimate loads acting alone, measured at the system component's center of gravity without structural damage to system components, fuel tanks, or their attachments that would leak fuel to an ignition source.

(a) *Drop test requirements.* Each tank, or the most critical tank, must be drop-tested as follows:

(1) The drop height must be at least 50 feet.

(2) The drop impact surface must be nondeforming.

(3) The tank must be filled with water to 80 percent of the normal, full capacity.

(4) The tank must be enclosed in a surrounding structure representative of the installation unless it can be established that the surrounding structure is free of projections or other design features likely to contribute to rupture of the tank.

(5) The tank must drop freely and impact in a horizontal position ±10°.

(6) After the drop test, there must be no leakage.

(b) *Fuel tank load factors.* Except for fuel tanks located so that tank rupture with fuel release to either significant ignition sources, such as engines, heaters, and auxiliary power units, or occupants is extremely remote, each fuel tank must be designed and installed to retain its contents under the following ultimate inertial load factors, acting alone.

(1) For fuel tanks in the cabin:

(i) Upward—4g.

(ii) Forward—16g.

(iii) Sideward—8g.

(iv) Downward—20g.

(2) For fuel tanks located above or behind the crew or passenger compartment that, if loosened, could injure an occupant in an emergency landing:

(i) Upward—1.5g.

(ii) Forward—8g.

(iii) Sideward—2g.

(iv) Downward—4g.

(3) For fuel tanks in other areas:

(i) Upward—1.5g.

(ii) Forward—4g.

(iii) Sideward—2g.

(iv) Downward—4g.

(c) *Fuel line self-sealing breakaway couplings.* Self-sealing breakaway couplings must be installed unless hazardous relative motion of fuel system components to each other or to local rotorcraft structure is demonstrated to be extremely improbable or unless other means are provided. The couplings or equivalent devices must be installed at all fuel tank-to-fuel line connections, tank-to-tank interconnects, and at other points in the fuel system where local structural deformation could lead to the release of fuel.

(1) The design and construction of self-sealing breakaway couplings must incorporate the following design features:

(i) The load necessary to separate a breakaway coupling must be between 25 to 50 percent of the minimum ultimate failure load (ultimate strength) of the weakest component in the fluid-carrying line. The separation load must in no case be less than 300 pounds, regardless of the size of the fluid line.

(ii) A breakaway coupling must separate whenever its ultimate load (as defined in paragraph (c)(1)(i) of this section) is applied in the failure modes most likely to occur.

(iii) All breakaway couplings must incorporate design provisions to visually ascertain that the coupling is locked together (leak-free) and is open during normal installation and service.

(iv) All breakaway couplings must incorporate design provisions to prevent uncoupling or unintended closing due to operational shocks, vibrations, or accelerations.

(v) No breakaway coupling design may allow the release of fuel once the coupling has performed its intended function.

(2) All individual breakaway couplings, coupling fuel feed systems, or equivalent means must be designed, tested, installed, and maintained so that inadvertent fuel shutoff in flight is improbable in accordance with § 29.955(a) and must comply with the fatigue evaluation requirements of § 29.571 without leaking.

(3) Alternate, equivalent means to the use of breakaway couplings must not create a survivable impact-induced load on the fuel line to which it is installed greater than 25 to 50 percent of the ultimate load (strength) of the weakest component in the line and must comply with the fatigue requirements of § 29.571 without leaking.

(d) *Frangible or deformable structural attachments.* Unless hazardous relative motion of fuel tanks and fuel system components to local rotorcraft structure is demonstrated to be extremely improbable in an otherwise survivable impact, frangible or locally deformable attachments of fuel tanks and fuel system components to local rotorcraft structure must be used. The attachment of fuel tanks and fuel system components to local rotorcraft structure, whether frangible or locally deformable, must be designed such that its separation or relative local deformation will occur without rupture or local tear-out of the fuel tank or fuel system components that will cause fuel leakage. The ultimate strength of frangible or deformable attachments must be as follows:

(1) The load required to separate a frangible attachment from its support structure, or deform a locally deformable attachment relative to its support structure, must be between 25 and 50 percent of the minimum ultimate load (ultimate strength) of the weakest component in the attached system. In no case may the load be less than 300 pounds.

(2) A frangible or locally deformable attachment must separate or locally deform as intended whenever its ultimate load (as defined in paragraph (d)(1) of this section) is applied in the modes most likely to occur.

(3) All frangible or locally deformable attachments must comply with the fatigue requirements of § 29.571.

(e) *Separation of fuel and ignition sources.* To provide maximum crash resistance, fuel must be located as far as practicable from all occupiable areas and from all potential ignition sources.

(f) *Other basic mechanical design criteria.* Fuel tanks, fuel lines, electrical wires, and electrical devices must be designed, constructed, and installed, as far as practicable, to be crash resistant.

(g) *Rigid or semirigid fuel tanks.* Rigid or semirigid fuel tank or bladder walls must be impact and tear resistant.]

[(Amdt. 29–35, Eff. 11/2/94)]

### § 29.953 Fuel system independence.

(a) For category A rotorcraft—

(1) The fuel system must meet the requirements of § 29.903(b); and

(2) Unless other provisions are made to meet paragraph (a)(1) of this section, the fuel system must allow fuel to be supplied to each engine through a system independent of those parts of each system supplying fuel to other engines.

(b) Each fuel system for a multiengine category B rotorcraft must meet the requirements of paragraph (a)(2) of this section. However, separate fuel tanks need not be provided for each engine.

### § 29.954 Fuel system lightning protection.

The fuel system must be designed and arranged to prevent the ignition of fuel vapor within the system by—

(a) Direct lightning strikes to areas having a high probability of stroke attachment;

(b) Swept lightning strokes to areas where swept strokes are highly probable; and

(c) Corona and streamering at fuel vent outlets.

[(Amdt. 29–26, Eff. 10/3/88)]

### § 29.955 Fuel flow.

(a) *General.* The fuel system for each engine must provide the engine with at least 100 percent of the fuel required under all operating and maneuvering conditions to be approved for the rotorcraft, including, as applicable, the fuel required to operate the engines under the test conditions required by § 29.927. Unless equivalent methods are used, compliance must be shown by test during which the following provisions are met, except that combinations of conditions which are shown to be improbable need not be considered.

(1) The fuel pressure, corrected for accelerations (load factors), must be within the limits specified by the engine type certificate data sheet.

(2) The fuel level in the tank may not exceed that established as the unusable fuel supply for that tank under § 29.959, plus that necessary to conduct the test.

(3) The fuel head between the tank and the engine must be critical with respect to rotorcraft flight attitudes.

(4) The fuel flow transmitter, if installed, and the critical fuel pump (for pump-fed systems) must be installed to produce (by actual or simulated failure) the critical restriction to fuel flow to be expected from component failure.

(5) Critical values of engine rotational speed, electrical power, or other sources of fuel pump motive power must be applied.

(6) Critical values of fuel properties which adversely affect fuel flow are applied during demonstrations of fuel flow capability.

(7) The fuel filter required by § 29.997 is blocked to the degree necessary to simulate the accumulation of fuel contamination required to activate the indicator required by § 29.1305(a)(17).

(b) *Fuel transfer system.* If normal operation of the fuel system requires fuel to be transferred to another tank, the transfer must occur automatically via a system which has been shown to maintain the fuel level in the receiving tank within acceptable limits during flight or surface operation of the rotorcraft.

(c) *Multiple fuel tanks.* If an engine can be supplied with fuel from more than one tank, the fuel system, in addition to having appropriate manual switching capability, must be designed to prevent interruption of fuel flow to the engine, without attention by the flightcrew, when any tank supplying fuel to that engine is depleted of usable fuel during normal operation and any other tank that normally supplies fuel to that engine alone contains usable fuel.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.957 Flow between interconnected tanks.

(a) Where tank outlets are interconnected and allow fuel to flow between them due to gravity or flight accelerations, it must be impossible for fuel to flow between tanks in quantities great enough to cause overflow from the tank vent in any sustained flight condition.

(b) If fuel can be pumped from one tank to another in flight—

(1) The design of the vents and the fuel transfer system must prevent structural damage to tanks from overfilling; and

(2) There must be means to warn the crew before overflow through the vents occurs.

### § 29.959 Unusable fuel supply.

The unusable fuel supply for each tank must be established as not less than the quantity at which the first evidence of malfunction occurs under the most adverse fuel feed condition occurring under any intended operations and flight maneuvers involving that tank.

### § 29.961 Fuel system hot weather operation.

Each suction lift fuel system and other fuel systems conducive to vapor formation must be shown to operate satisfactorily (within certification limits) when using fuel at the most critical temperature for vapor formation under critical operating conditions including, if applicable, the engine operating conditions defined by § 29.927(b)(1) and (b)(2).

(d) If compliance with paragraph (b) of this section is shown in weather cold enough to interfere with the proper conduct of the test, each fuel tank surface, fuel line, and other fuel system parts subject to cold air must be insulated to simulate, insofar as practicable, flight in hot weather.

[(Amdt. 29–26, Eff. 10/3/88)]

### § 29.963 Fuel tanks: General.

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads to which it may be subjected in operation.

[(b)] [Each flexible fuel tank bladder or liner must be approved or shown to be suitable for the particular application and must be puncture resistant. Puncture resistance must be shown by meeting the TSO–C80, paragraph 16.0, requirements using a minimum puncture force of 370 pounds.]

([c]) Each integral fuel tank liner must have facilities for inspection and repair of its interior.

([d]) The maximum exposed surface temperature of all components in the fuel tank must be less by a safe margin than the lowest expected autoignition temperature of the fuel or fuel vapor in the tank. Compliance with this requirement must be shown under all operating conditions and under all normal or malfunction conditions of all components inside the tank.

[(e) Each fuel tank installed in personnel compartments must be isolated by fume-proof and fuel-proof enclosures that are drained and vented to the exterior of the rotorcraft. The design and construction of the enclosures must provide necessary protection for the tank, must be crash resistant during a survivable impact in accordance with § 29.952, and must be adequate to withstand loads and abrasions to be expected in personnel compartments.]

(Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–35, Eff. 11/2/94)]

### § 29.965 Fuel tank tests.

(a) Each fuel tank must be able to withstand the applicable pressure tests in this section without failure or leakage. If practicable, test pressures may be applied in a manner simulating the pressure distribution in service.

(b) Each conventional metal tank, each nonmetallic tank with walls that are not supported by the rotorcraft structure, and each integral tank must be subjected to a pressure of 3.5 p.s.i. unless the pressure developed during maximum limit acceleration or emergency deceleration with a full tank exceeds this value, in which case a hydrostatic head, or equivalent test, must be applied to duplicate the acceleration loads as far as possible. However, the pressure need not exceed 3.5 p.s.i. on surfaces not exposed to the acceleration loading.

(c) Each nonmetallic tank with walls supported by the rotorcraft structure must be subjected to the following tests:

(1) A pressure test of at least 2.0 p.s.i. This test may be conducted on the tank alone in conjunction with the test specified in paragraph (c)(2) of this section.

(2) A pressure test, with the tank mounted in the rotorcraft structure, equal to the load developed by the reaction of the contents, with the tank full, during maximum limit acceleration or emergency deceleration. However, the pressure need not exceed 2.0 p.s.i. on surfaces not exposed to the acceleration loading.

(d) Each tank with large unsupported or unstiffened flat areas, or with other features whose failure or deformation could cause leakage, must be subjected to the following test or its equivalent:

(1) Each complete tank assembly and its supports must be vibration tested while mounted to simulate the actual installation.

(2) The tank assembly must be vibrated for 25 hours while two-thirds full of any suitable fluid. The amplitude of vibration may not be less than one thirty-second of an inch unless otherwise substantiated.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the test frequency of vibration, in number of cycles per minute, must, unless a frequency based on a more rational analysis is used, be the number obtained by averaging the maximum and minimum power-on engine speeds (r.p.m.) for reciprocating engine powered rotorcraft or 2,000 c.p.m. for turbine engine powered rotorcraft.

(ii) If only one frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, that frequency of vibration must be the test frequency.

(iii) If more than one frequency of vibration resulting from any r.p.m. within the normal operating range of engine or rotor system speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under paragraph (d)(3)(ii) and (iii), the time of test must be adjusted to accomplish the same number of vibration cycles as would be accomplished in 25 hours at the frequency specified in paragraph (d)(3)(i) of this section.

(5) During the test, the tank assembly must be rocked at the rate of 16 to 20 complete cycles per minute through an angle of 15° on both sides of the horizontal (30° total), about the most critical axis, for 25 hours). If motion about more than one axis is likely to be critical, the tank must be rocked about each critical axis for 12½ hours.

[(Amdt. 29–13, Eff. 5/2/77)]

### § 29.967 Fuel tank installation.

(a) Each fuel tank must be supported so that tank loads are not concentrated on unsupported tank surfaces. In addition—

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports;

(2) The padding must be nonabsorbent or treated to prevent the absorption of fuel;

(3) If flexible tank liners are used, they must be supported so that they are not required to withstand fluid loads; and

(4) Each interior surface of tank compartments must be smooth and free of projections that could cause wear of the liner, unless—

(i) There are means for protection of the liner at those points; or

(ii) The construction of the liner itself provides such protection.

(b) Any spaces adjacent to tank surfaces must be adequately ventilated to avoid accumulation of fuel or fumes in those spaces due to minor leakage. If the tank is in a sealed compartment, ventilation may be limited to drain holes that prevent clogging and that prevent excessive pressure resulting from altitude changes. If flexible tank liners are installed, the venting arrangement for the spaces between the liner and its container must maintain the proper relationship to tank vent pressures for any expected flight condition.

(c) The location of each tank must meet the requirements of § 29.1185(b) and (c).

(d) No rotorcraft skin immediately adjacent to a major air outlet from the engine compartment may act as the wall of an integral tank.

(e) [Removed]

(Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–35, Eff. 11/2/94)]

### § 29.969 Fuel tank expansion space.

Each fuel tank or each group of fuel tanks with interconnected vent systems must have an expansion space of not less than 2 percent of the combined tank capacity. It must be impossible to fill the fuel tank expansion space inadvertently with the rotorcraft in the normal ground attitude.

[(Amdt. 29–26, Eff. 10/3/88)]

### § 29.971 Fuel tank sump.

(a) Each fuel tank must have a sump with a capacity of not less than the greater of—

(1) 0.10 percent of the tank capacity of—

(2) One-sixteenth gallon.

(b) The capacity prescribed in paragraph (a) of this section must be effective with the rotorcraft in any normal attitude, and must be located so that the sump contents cannot escape through the tank outlet opening.

(c) Each fuel tank must allow drainage of hazardous quantities of water from each part of the tank to the sump with the rotorcraft in any ground attitude to be expected in service.

(d) Each fuel tank sump must have a drain that allows complete drainage of the sump on the ground.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.973 Fuel tank filler connection.

(a) [Each fuel tank filler connection must prevent the entrance of fuel into any part of the rotorcraft other than the tank itself during normal operations and must be crash resistant during a survivable impact in accordance with § 29.952(c). In addition—

(1) Each filler must be marked as prescribed in § 29.1557(c)(1);

(2) Each recessed filler connection that can retain any appreciable quantity of fuel must have a drain that discharges clear of the entire rotorcraft; and

(3) Each filler cap must provide a fuel-tight seal under the fluid pressure expected in normal operation and in a survivable impact.

(b) Each filler cap or filler cap cover must warn when the cap is not fully locked or seated on the filler connection.]

[(Amdt. 29–35, Eff. 11/2/94)]

### § 29.975 Fuel tank vents and carburetor vapor vents.

(a) *Fuel tank vents.* Each fuel tank must be vented from the top part of the expansion space so that venting is effective under normal flight conditions. In addition—

(1) The vents must be arranged to avoid stoppage by dirt or ice formation;

(2) The vent arrangement must prevent siphoning of fuel during normal operation;

(3) The venting capacity and vent pressure levels must maintain acceptable differences of pressure between the interior and exterior of the tank during—

(i) Normal flight operation;

(ii) Maximum rate of ascent and descent; and

(iii) Refueling and defueling (where applicable);

(4) Airspaces of tanks with interconnected outlets must be interconnected;

(5) There may be no point in any vent line where moisture can accumulate with the rotorcraft in the ground attitude or the level flight attitude, unless drainage is provided;

(6) No vent or drainage provision may end at any point—

(i) Where the discharge of fuel from the vent outlet would constitute a fire hazard; or

(ii) From which fumes could enter personnel compartments; and

(7) [The venting system must be designed to minimize spillage of fuel through the vents to an ignition source in the event of a rollover during landing, ground operations, or a survivable impact, unless a rollover is shown to be extremely remote.]

(b) *Carburetor vapor vents.* Each carburetor with vapor elimination connections must have a vent line to lead vapors back to one of the fuel tanks. In addition—

(1) Each vent system must have means to avoid stoppage by ice; and

(2) If there is more than one fuel tank, and it is necessary to use the tanks in a definite sequence, each vapor vent return line must lead back to the fuel tank used for takeoff and landing.

(Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–35, Eff. 11/2/94)]

### § 29.977 Fuel tank outlet.

(a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must—

(1) For reciprocating engine powered airplanes, have 8 to 16 meshes per inch; and

(2) For turbine engine powered airplanes, prevent the passage of any object that could restrict fuel flow or damage any fuel system component.

(b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.979 Pressure refueling and fueling provisions below fuel level.

(a) Each fueling connection below the fuel level in each tank must have means to prevent the escape of hazardous quantities of fuel from that tank in case of malfunction of the fuel entry valve.

(b) For systems intended for pressure refueling, a means in addition to the normal means for limiting the tank content must be installed to prevent damage to the tank in case of failure of the normal means.

(c) The rotorcraft pressure fueling system (not fuel tanks and fuel tank vents) must withstand an ultimate load that is 2.0 times the load arising from the maximum pressure, including surge, that is likely to occur during fueling. The maximum surge pressure must be established with any combination of tank valves being either intentionally or inadvertently closed.

(d) The rotorcraft defueling system (not including fuel tanks and fuel tank vents) must withstand an ultimate load that is 2.0 times the load arising from the maximum permissible defueling pressure (positive or negative) at the rotorcraft fueling connection.

[(Amdt. 29–12, Eff. 2/1/77)]

## FUEL SYSTEM COMPONENTS

### § 29.991 Fuel pumps.

(a) Compliance with § 29.955 must not be jeopardized by failure of—

(1) Any one pump except pumps that are approved and installed as parts of a type certificated engine; or

(2) Any component required for pump operation except the engine served by that pump.

(b) The following fuel pump installation requirements apply:

(1) When necessary to maintain the proper fuel pressure—

(i) A connection must be provided to transmit the carburetor air intake static pressure to the proper fuel pump relief valve connection; and

(ii) The gauge balance lines must be independently connected to the carburetor inlet pressure to avoid incorrect fuel pressure readings.

(2) The installation of fuel pumps having seals or diaphragms that may leak must have means for draining leaking fuel.

(3) Each drain line must discharge where it will not create a fire hazard.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.993 Fuel system lines and fittings.

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure, valve actuation, and accelerated flight conditions.

(b) Each fuel line connected to components of the rotorcraft between which relative motion could exist must have provisions for flexibility.

(c) Each flexible connection in fuel lines that may be under pressure or subjected to axial loading must use flexible hose assemblies.

(d) Flexible hose must be approved.

(e) No flexible hose that might be adversely affected by high temperatures may be used where excessive temperatures will exist during operation or after engine shutdown.

### § 29.995 Fuel valves.

In addition to meeting the requirements of § 29.1189, each fuel valve must—

(a) [Reserved]

(b) Be supported so that no loads resulting from their operation or from accelerated flight conditions are transmitted to the lines attached to the valve. [(Amdt. 29–13, Eff. 5/2/77)]

### § 29.997 Fuel strainer or filter.

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of the first fuel system component which is susceptible to fuel contamination, including but not limited to the fuel metering device or an engine positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must—

(a) Be accessible for draining and cleaning and must incorporate a screen or element which is easily removable;

(b) Have a sediment trap and drain, except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself, unless adequate strength margins under all loading conditions are provided in the lines and connections; and

(d) Provide a means to remove from the fuel any contaminant which would jeopardize the flow of fuel through rotorcraft or engine fuel system components required for proper rotorcraft or engine fuel system components required for proper rotorcraft or engine fuel system operation.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.999 Fuel system drains.

(a) There must be at least one accessible drain at the lowest point in each fuel system to completely drain the system with the rotorcraft in any ground attitude to be expected in service.

(b) Each drain required by paragraph (a) of this section including the drains prescribed in § 29.971 must—

(1) Discharge clear of all parts of the rotorcraft;

(2) Have manual or automatic means to ensure positive closure in the off position; and

(3) Have a drain valve—

(i) That is readily accessible and which can be easily opened and closed; and

(ii) That is either located or protected to prevent fuel spillage in the vent of a landing with landing gear retracted.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1001 Fuel jettisoning.

If a fuel jettisoning system is installed, the following apply:

(a) Fuel jettisoning must be safe during all flight regimes for which jettisoning is to be authorized.

(b) In showing compliance with paragraph (a) of this section, it must be shown that—

(1) The fuel jettisoning system and its operation are free from fire hazard;

(2) No hazard results from fuel or fuel vapors which impinge on any part of the rotorcraft during fuel jettisoning; and

(3) Controllability of the rotorcraft remains satisfactory throughout the fuel jettisoning operation.

(c) Means must be provided to automatically prevent jettisoning fuel below the level required for an all-engine climb at maximum continuous power from sea level to 5,000 feet altitude and cruise thereafter for 30 minutes at maximum range engine power.

(d) The controls for any fuel jettisoning system must be designed to allow flight personnel (minimum crew) to safely interrupt fuel jettisoning during any part of the jettisoning operation.

(e) The fuel jettisoning system must be designed to comply with the powerplant installation requirements of § 29.901(c).

(f) An auxiliary fuel jettisoning system which meets the requirements of paragraphs (a), (b), (d), and (e) of this section may be installed to jettison additional fuel provided it has separate and independent controls.

[(Amdt. 29–26, Eff. 10/3/88)]

## OIL SYSTEM

### § 29.1011 Engines: General.

(a) Each engine must have an independent oil system that can supply it with an appropriate quantity of oil at a temperature not above that safe for continuous operation.

(b) The usable oil capacity of each system may not be less than the product of the endurance of the rotorcraft under critical operating conditions and the maximum allowable oil consumption of the engine under the same conditions, plus a suitable margin to ensure adequate circulation and cooling. Instead of a rational analysis of endurance and consumption, a usable oil capacity of one gallon for each 40 gallons of usable fuel may be used for reciprocating engine installations.

(c) Oil-fuel ratios lower than those prescribed in paragraph (c) of this section may be used if they are substantiated by data on the oil consumption of the engine.

(d) The ability of the engine oil cooling provisions to maintain the oil temperature at or below the maximum established value must be shown under the applicable requirements of §§ 29.1041 through 29.1049.

[(Amdt. 29–26, Eff. 10/3/88)]

### § 29.1013 Oil tanks.

(a) *Installation.* Each oil tank installation must meet the requirements of § 29.967.

(b) *Expansion space.* Oil tank expansion space must be provided so that—

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10 percent of the tank capacity of 0.5 gallon, and each oil tank used with a turbine engine has an expansion space of not less than 10 percent of the tank capacity;

(2) Each reserve oil tank not directly connected to any engine has an expansion space of not less than 2 percent of the tank capacity; and

(3) It is impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude.

(c) *Filler connection.* Each recessed oil tank filler connection that can retain any appreciable quantity of oil must have a drain that discharges clear of the entire rotorcraft. In addition—

(1) Each oil tank filler cap must provide an oil-tight seal under the pressure expected in operation;

(2) For category A rotorcraft, each oil tank filler cap or filler cap cover must incorporate features that provide a warning when caps are not fully locked or seated on the filler connection; and

(3) Each oil filler must be marked under § 29.1557(c)(2).

(d) *Vent.* Oil tanks must be vented as follows:

(1) Each oil tank must be vented from the top part of the expansion space so that venting is effective under all normal flight conditions.

(2) Oil tank vents must be arranged so that condensed water vapor that might freeze and obstruct the line cannot accumulate at any point.

(e) *Outlet.* There must be means to prevent entrance into the tank itself, or into the tank outlet, of any object that might obstruct the flow of oil through the system. No oil tank outlet may be enclosed by a screen or guard that would reduce the flow of oil below a safe value at any operating temperature. There must be a shutoff valve at the outlet of each oil tank used with a turbine engine unless the external portion of the oil system (including oil tank supports) is fireproof.

(f) *Flexible liners.* Each flexible oil tank liner must be approved or shown to be suitable for the particular installation.

[(Amdt. 29–10, Eff. 10/31/74)]

### § 29.1015 Oil tank tests.

Each oil tank must be designed and installed so that—

(a) It can withstand, without failure, any vibration, inertia, and fluid loads to which it may be subjected in operation; and

(b) It meets the requirements of § 29.965, except that instead of the pressure specified in § 29.965(b)—

(1) For pressurized tanks used with a turbine engine, the test pressure may not be less than 5 p.s.i. plus the maximum operating pressure of the tank; and

(2) For all other tanks, the test pressure may not be less than 5 p.s.i.

[(Amdt. 29–10, Eff. 10/31/74)]

### § 29.1017 Oil lines and fittings.

(a) Each oil line must meet the requirements of § 29.993.

(b) Breather lines must be arranged so that—

(1) Condensed water vapor that might freeze and obstruct the line cannot accumulate at any point;

(2) The breather discharge will not constitute a fire hazard if foaming occurs, or cause emitted oil to strike the pilot's windshield; and

(3) The breather does not discharge into the engine air induction system.

### § 29.1019 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitation established for the engine) to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine under part 33 of this chapter.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate a means to indicate contamination before it reaches the capacity established in accordance with paragraph (a)(2) of this section.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 29.1305(a)(18).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

[(Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1021 Oil system drains.

A drain (or drains) must be provided to allow safe drainage of the oil system. Each drain must—

(a) Be accessible; and

(b) Have manual or automatic means for positive locking in the closed position.

[(Amdt. 29–22, Eff. 3/26/84)]

### § 29.1023 Oil radiators.

(a) Each oil radiator must be able to withstand any vibration, inertia, and oil pressure loads to which it would be subjected in operation.

(b) Each oil radiator air duct must be located, or equipped, so that, in case of fire, and with the airflow as it would be with and without the engine operating, flames cannot directly strike the radiator.

### § 29.1025 Oil valves.

(a) Each oil shutoff must meet the requirements of § 29.1189.

(b) The closing of oil shutoffs may not prevent autorotation.

(c) Each oil valve must have positive stops or suitable index provisions in the "on" and "off" positions and must be supported so that no loads resulting from its operation or from accelerated flight conditions are transmitted to the lines attached to the valve.

### § 29.1027 Transmission and gearboxes: General.

(a) The oil system for components of the rotor drive system that require continuous lubrication must be sufficiently independent of the lubrication systems of the engine(s) to ensure—

(1) Operation with any engine inoperative; and

(2) Safe autorotation.

(b) Pressure lubrication systems for transmissions and gearboxes must comply with the requirements of §§ 29.1013, paragraphs (c), (d), and (f) only, 29.1015, 29.1017, 29.1021, 29.1023, and 29.1337(d). In addition, the system must have—

(1) An oil strainer or filter through which all the lubricant flows, and must—

(i) Be designed to remove from the lubricant any contaminant which may damage transmission and drive system components or impede the flow of lubricant to a hazardous degree; and

(ii) Be equipped with a bypass constructed and installed so that—

(A) The lubricant will flow at the normal rate through the rest of the system with the strainer or filter completely blocked; and

(B) The release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flowpath;

(iii) Be equipped with a means to indicate collection of contaminants on the filter or strainer at or before opening of the bypass;

(2) For each lubricant tank or sump outlet supplying lubrication to rotor drive systems and rotor drive system components, a screen to prevent entrance into the lubrication system of any object that might obstruct the flow of lubricant from the outlet to the filter required by paragraph (b)(1) of this section. The requirements of paragraph (b)(1) of this section do not apply to screens installed at lubricant tank or sump outlets.

(c) Splash type lubrication systems for rotor drive system gearboxes must comply with §§ 29.1021 and 29.1337(d).

[(Amdt. 29–26, Eff. 10/3/88)]

## COOLING

### § 29.1041 General.

(a) The powerplant and auxiliary power unit cooling provisions must be able to maintain the temperatures of power plant components, engine fluids, and auxiliary power unit components and fluids within the temperature limits established for these components and fluids, under ground, water, and flight operating conditions for which certification is requested, and after normal engine or auxiliary power shutdown, or both.

(b) There must be cooling provisions to maintain the fluid temperatures in any power transmission within safe values under any critical surface (ground or water) and flight operating conditions.

(c) Except for ground-use-only auxiliary power units, compliance with paragraphs (a) and (b) of this section must be shown by flight tests in which the temperatures of selected powerplant component and auxiliary power unit component, engine, and transmission fluids are obtained under the conditions prescribed in those paragraphs.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1043 Cooling tests.

(a) *General.* For the tests prescribed in § 29.1041(c), the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in paragraph (b) of this section, the recorded powerplant temperatures must be corrected under paragraphs (c) and (d) of this section, unless a more rational correction method is applicable.

(2) No corrected temperature determined under paragraph (a)(1) of this section may exceed established limits.

(3) The fuel used during the cooling tests must be of the minimum grade approved for the engines, and the mixture settings must be those used in normal operation.

(4) The test procedures must be as prescribed in §§ 29.1045 through 29.1049.

(5) For the purposes of the cooling tests, a temperature is "stabilized" when its rate of change is less than 2°F per minute.

(b) *Maximum ambient atmospheric temperature.* A maximum ambient atmospheric temperature corresponding to sea level conditions of at least 100 degrees F. must be established. The assumed temperature lapse rate is 3.6 degrees F. per thousand feet of altitude above sea level until a temperature of −69.7 degrees F. is reached, above which altitude the temperature is considered constant at −69.7 degrees F. However, for winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 100 degrees F.

(c) *Correction factor (except cylinder barrels).* Unless a more rational correction applies, temperatures of engine fluids and powerplant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum component or fluid temperature recorded during the cooling test.

(d) *Correction factor for cylinder barrel temperatures.* Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1045 Climb cooling test procedures.

(a) Climb cooling tests must be conducted under this section for—

(1) Category A rotorcraft; and

(2) Multiengine category B rotorcraft for which certification is requested under the category A powerplant installation requirements, and under the requirements of § 29.861(a) at the steady rate of climb or descent established under § 29.67(b).

(b) The climb or descent cooling tests must be conducted with the engine inoperative that produces the most adverse cooling conditions for the remaining engines and powerplant components.

(c) Each operating engine must—

(1) For helicopters for which the use of 30-minute OEI power is requested, be at 30-minute OEI power for 30 minutes, and then at maximum continuous power (or at full throttle when above the critical altitude);

(2) For helicopters for which the use of continuous OEI power is requested, be at continuous OEI power (or at full throttle when above the critical altitude); and

(3) For other rotorcraft, be at maximum continuous power (or at full throttle when above the critical altitude).

(d) After temperatures have stabilized in flight, the climb must be—

(1) Begun from an altitude not greater than the lower of—

(i) 1,000 feet below the engine critical altitude; and

(ii) 1,000 feet below the maximum altitude at which the rate of climb is 150 f.p.m.; and

(2) Continued for at least 5 minutes after the occurrence of the highest temperature recorded, or until the rotorcraft reaches the maximum altitude for which certification is requested.

(e) For category B rotorcraft without a positive rate of climb, the descent must begin at the all-engine-critical altitude and end at the higher of—

(1) The maximum altitude at which level flight can be maintained with one engine operative; and

(2) Sea level.

(f) The climb or descent must be conducted at an airspeed representing a normal operational practice for the configuration being tested. However, if the cooling provisions are sensitive to rotorcraft speed, the most critical airspeed must be used, but need not exceed the speeds established under § 29.67(a)(2) or § 29.67(b). The climb cooling test may be conducted in conjunction with the takeoff cooling test of § 29.1047.

[(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1047 Takeoff cooling test procedures.

(a) *Category A.* For each category A rotorcraft, cooling must be shown during takeoff and subsequent climb as follows:

(1) Each temperature must be stabilized while hovering in ground effect with—

(i) The power necessary for hovering;

(ii) The appropriate cowl flap and shutter settings; and

(iii) The maximum weight.

(2) After the temperatures have stabilized, a climb must be started at the lowest practicable altitude and must be conducted with one engine inoperative.

(3) The operating engines must be at the greatest power for which approval is sought (or at full throttle when above the critical altitude) for the same period as this power is used in determining the takeoff climbout path under § 29.59.

(4) At the end of the time interval prescribed in paragraph (b)(3) of this section, the power must be changed to that used in meeting § 29.67(a)(2) and the climb must be continued for—

(i) Thirty minutes, if 30-minute OEI power is used; or

(ii) At least 5 minutes after the occurrence of the highest temperature recorded, if continuous OEI power or maximum continuous power is used.

(5) The speeds must be those used in determining the takeoff flight path under § 29.59.

(b) *Category B.* For each category B rotorcraft, cooling must be shown during takeoff and subsequent climb as follows:

(1) Each temperature must be stabilized while hovering in ground effect with—

(i) The power necessary for hovering;

(ii) The appropriate cowl flap and shutter settings; and

(iii) The maximum weight.

(2) After the temperatures have stabilized, a climb must be started at the lowest practicable altitude with takeoff power.

(3) Takeoff power must be used for the same time interval as takeoff power is used in determining the takeoff flight path under § 29.63.

(4) At the end of the time interval prescribed in paragraph (a)(3) of this section, the power must be reduced to maximum continuous power and the climb must be continued for at least five minutes after the occurrence of the highest temperature recorded.

(5) The cooling test must be conducted at an airspeed corresponding to normal operating practice for the configuration being tested. However, if the cooling provisions are sensitive to rotorcraft speed, the most critical airspeed must be used, but need not exceed the speed for best rate of climb with maximum continuous power.

[(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1049 Hovering cooling test procedures.

The hovering cooling provisions must be shown—

(a) At maximum weight or at the greatest weight at which the rotorcraft can hover (if less), at sea level, with the power required to hover but not more than maximum continuous power, in the ground effect in still air, until at least five minutes after the occurrence of the highest temperature recorded; and

(b) With maximum continuous power, maximum weight, and at the altitude resulting in zero rate of climb for this configuration, until at least five minutes after the occurrence of the highest temperature recorded.

## INDUCTION SYSTEM

### § 29.1091 Air induction.

(a) The air induction system for each engine and auxiliary power unit must supply the air required by that engine and auxiliary power unit under the operating conditions for which certification is requested.

(b) Each engine and auxiliary power unit air induction system must provide air for proper fuel metering and mixture distribution with the induction system valves in any position.

(c) No air intake may open within the engine accessory section or within other areas of any powerplant compartment where emergence of backfire flame would constitute a fire hazard.

(d) Each reciprocating engine must have an alternate air source.

(e) Each alternate air intake must be located to prevent the entrance of rain, ice, or other foreign matter.

(f) For turbine engine powered rotorcraft and rotorcraft incorporating auxiliary power units—

(1) There must be means to prevent hazardous quantities of fuel leakage or overflow from drains, vents, or other components of flammable fluid systems from entering the engine or auxiliary power unit intake system; and

(2) The air inlet ducts must be located or protected so as to minimize the ingestion of foreign matter during takeoff, landing, and taxiing.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–17, Eff. 12/1/78)]

### § 29.1093 Induction system icing protection.

(a) *Reciprocating engines.* Each reciprocating engine air induction system must have means to prevent and eliminate icing. Unless this is done by other means, it must be shown that, in air free of visible moisture at a temperature of 30° F., and with the engines at 60 percent of maximum continuous power—

(1) Each rotorcraft with sea level engines using conventional venturi carburetors has a preheater that can provide a heat rise of 90° F.;

(2) Each rotorcraft with sea level engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of 70° F.;

(3) Each rotorcraft with altitude engines using conventional venturi carburetors has a preheater that can provide a heat rise of 120° F.; and

(4) Each rotorcraft with altitude engines using carburetors tending to prevent icing has a preheater that can provide a heat rise of 100° F.

(b) *Turbine engines.* (1) It must be shown that each turbine engine and its air inlet system can operate throughout the flight power range of the engine (including idling)—

(i) Without accumulating ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power under the icing conditions specified in appendix C of this part; and

(ii) In snow, both falling and blowing, without adverse effect on engine operation, within the limitations established for the rotorcraft.

(2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30°

F (between $-9°$ and $-1°$ C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter not less than 20 microns, followed by momentary operation at takeoff power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.

(c) *Supercharged reciprocating engines.* For each engine having a supercharger to pressurize the air before it enters the carburetor, the heat rise in the air caused by that supercharging at any altitude may be utilized in determining compliance with paragraph (a) of this section if the heat rise utilized is that which will be available, automatically, for the applicable altitude and operation condition because of supercharging.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1101 Carburetor air preheater design.

Each carburetor air preheater must be designed and constructed to—

(a) Ensure ventilation of the preheater when the engine is operated in cold air;

(b) Allow inspection of the exhaust manifold parts that it surrounds; and

(c) Allow inspection of critical parts of the preheater itself.

### § 29.1103 Induction systems ducts and air duct systems.

(a) Each induction system duct upstream of the first stage of the engine supercharger and of the auxiliary power unit compressor must have a drain to prevent the hazardous accumulation of fuel and moisture in the ground attitude. No drain may discharge where it might cause a fire hazard.

(b) Each duct must be strong enough to prevent induction system failure from normal backfire conditions.

(c) Each duct connected to components between which relative motion could exist must have means for flexibility.

(d) Each duct within any fire zone for which a fire-extinguishing system is required must be at least—

(1) Fireproof, if it passes through any firewall; or

(2) Fire resistant, for other ducts, except that ducts for auxiliary power units must be fireproof within the auxiliary power unit fire zone.

(e) Each auxiliary power unit induction system duct must be fireproof for a sufficient distance upstream of the auxiliary power unit compartment to prevent hot gas reverse flow from burning through auxiliary power unit ducts and entering any other compartment or area of the rotorcraft in which a hazard would be created resulting from the entry of hot gases. The materials used to form the remainder of the induction system duct and plenum chamber of the auxiliary power unit must be capable of resisting the maximum heat conditions likely to occur.

(f) Each auxiliary power unit induction system duct must be constructed of materials that will not absorb or trap hazardous quantities of flammable fluids that could be ignited in the event of a surge or reverse flow condition.

[(Amdt. 29–17, Eff. 12/1/78)]

### § 29.1105 Induction system screens.

If induction system screens are used—

(a) Each screen must be upstream of the carburetor;

(b) No screen may be in any part of the induction system that is the only passage through which air can reach the engine, unless it can be deiced by heated air;

(c) No screen may be deiced by alcohol alone; and

(d) It must be impossible for fuel to strike any screen.

### § 29.1107 Inter-coolers and after-coolers.

Each inter-cooler and after-cooler must be able to withstand the vibration, inertia, and air pressure loads to which it would be subjected in operation.

### § 29.1109 Carburetor air cooling.

It must be shown under § 29.1043 that each installation using two-stage superchargers has means to maintain the air temperature, at the carburetor inlet, at or below the maximum established value.

## EXHAUST SYSTEM

### § 29.1121 General.

For powerplant and auxiliary power unit installations the following apply:

(a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in any personnel compartment.

(b) Each exhaust system part with a surface hot enough to ignite flammable fluids or vapors must be located or shielded so that leakage from any system carrying flammable fluids or vapors will not result in a fire caused by impingement of the fluids or vapors on any part of the exhaust system including shields for the exhaust system.

(c) Each component upon which hot exhaust gases could impinge, or that could be subjected to high temperatures from exhaust system parts, must be fireproof. Each exhaust system component must be separated by a fireproof shield from adjacent parts of the rotorcraft that are outside the engine and auxiliary power unit compartments.

(d) No exhaust gases may discharge so as to cause a fire hazard with respect to any flammable fluid vent or drain.

(e) No exhaust gases may discharge where they will cause a glare seriously affecting pilot vision at night.

(f) Each exhaust system component must be ventilated to prevent points of excessively high temperature.

(g) Each exhaust shroud must be ventilated or insulated to avoid, during normal operation, a temperature high enough to ignite any flammable fluids or vapors outside the shroud.

(h) If significant traps exist, each turbine engine exhaust system must have drains discharging clear of the rotorcraft, in any normal ground and flight attitudes, to prevent fuel accumulation after the failure of an attempted engine start.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77)]

### § 29.1123 Exhaust piping.

(a) Exhaust piping must be heat and corrosion resistant, and must have provisions to prevent failure due to expansion by operating temperatures.

(b) Exhaust piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operation.

(c) Exhaust piping connected to components between which relative motion could exist must have provisions for flexibility.

### § 29.1125 Exhaust heat exchangers.

For reciprocating engine powered rotorcraft the following apply:

(a) Each exhaust heat exchanger must be constructed and installed to withstand the vibration, inertia, and other loads to which it would be subjected in operation. In addition—

(1) Each exchanger must be suitable for continued operation at high temperatures and resistant to corrosion from exhaust gases:

(2) There must be means for inspecting the critical parts of each exchanger;

(3) Each exchanger must have cooling provisions wherever it is subject to contact with exhaust gases; and

(4) Each exhaust heat exchanger muff may have stagnant areas or liquid traps that would increase the probability of ignition of flammable fluids or vapors that might be present in case of the failure or malfunction of components carrying flammable fluids.

(b) If an exhaust heat exchanger is used for heating ventilating air used by personnel—

(1) There must be a secondary heat exchanger between the primary exhaust gas heat exchanger and the ventilating air system; or

(2) Other means must be used to prevent harmful contamination of the ventilating air.

[(Amdt. 29–12, Eff. 2/1/77)]

## POWERPLANT CONTROLS AND ACCESSORIES

### § 29.1141 Powerplant controls: General.

(a) Powerplant controls must be located and arranged under § 29.777 and marked under § 29.1555.

(b) Each control must be located so that it cannot be inadvertently operated by persons entering, leaving, or moving normally in the cockpit.

(c) Each flexible powerplant control must be approved.

(d) Each control must be able to maintain any set position without—

(1) Constant attention; or

(2) Tendency to creep due to control loads or vibration.

(e) Each control must be able to withstand operating loads without excessive deflection.

(f) Controls of powerplant valves required for safety must have—

(1) For manual valves, positive stops or in the case of fuel valves suitable index provisions, in the open and closed position; and

(2) For power-assisted valves, a means to indicate to the flight crew when the valve—

(i) Is in the fully open or fully closed position; or

(ii) Is moving between the fully open and fully closed position.

[(Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1142 Auxiliary power unit controls.

Means must be provided on the flight deck for starting, stopping, and emergency shutdown of each installed auxiliary power unit.

[(Amdt. 29–17, Eff. 12/1/78)]

### § 29.1143 Engine controls.

(a) There must be a separate power control for each engine.

(b) Power controls must be arranged to allow ready synchronization of all engines by—

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(c) Each power control must provide a positive and immediately responsive means of controlling its engine.

(d) Each fluid injection control other than fuel system control must be in the corresponding power control. However, the injection system pump may have a separate control.

(e) if a power control incorporates a fuel shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. The means must—

(1) Have a positive lock or stop at the idle position; and

(2) Require a separate and distinct operation to place the control in the shutoff position.

[(f) For rotorcraft to be certificated for a 30-second OEI power rating, a means must be provided to automatically activate and control the 30-second OEI power and prevent any engine from exceeding the installed engine limits associated with the 30-second OEI power rating approved for the rotorcraft.]

(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–34, Eff. 10/17/94)]

### § 29.1145 Ignition switches.

(a) Ignition switches must control each ignition circuit on each engine.

(b) There must be means to quickly shut off all ignition by the grouping of switches or by a master ignition control.

(c) Each group of ignition switches, except ignition switches for turbine engines with continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation.

[(Amdt. 29–13, Eff. 5/2/77)]

### § 29.1147 Mixture controls.

(a) If there are mixture controls, each engine must have a separate control, and the controls must be arranged to allow—

(1) Separate control of each engine; and

(2) Simultaneous control of all engines.

(b) Each intermediate position of the mixture controls that corresponds to a normal operating setting must be identifiable by feel and sight.

### § 29.1151 Rotor brake controls.

(a) It must be impossible to apply the rotor brake inadvertently in flight.

(b) There must be means to warn the crew if the rotor brake has not been completely released before takeoff.

### § 29.1157 Carburetor air temperature controls.

There must be a separate carburetor air temperature control for each engine.

### § 29.1159 Supercharger controls.

Each supercharger control must be accessible to—

(a) The pilots; or

(b) (If there is a separate flight engineer station with a control panel) the flight engineer.

### § 29.1163 Powerplant accessories.

(a) Each engine mounted accessory must—

(1) Be approved for mounting on the engine involved;

(2) Use the provisions on the engine for mounting; and

(3) Be sealed in such a way as to prevent contamination of the engine oil system and the accessory system.

(b) Electrical equipment subject to arcing or sparking must be installed to minimize the probability of igniting flammable fluids or vapors.

(c) If continued rotation of an engine-driven cabin supercharger or any remote accessory driven by the engine will be a hazard if they malfunction, there must be means to prevent their hazardous rotation without interfering with the continued operation of the engine.

(d) Unless other means are provided, torque limiting means must be provided for accessory drives located on any component of the transmission and rotor drive system to prevent damage to these components from excessive accessory load.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–22, Eff. 3/26/84); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1165 Engine ignition systems.

(a) Each battery ignition system must be supplemented with a generator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted.

(b) The capacity of batteries and generators must be large enough to meet the simultaneous demands of the engine ignition system and the greatest demands of any electrical system components that draw from the same source.

(c) The design of the engine ignition system must account for—

(1) The condition of an inoperative generator;

(2) The condition of a completely depleted battery with the generator running at its normal operating speed; and

(3) The condition of a completely depleted battery with the generator operating at idling speed, if there is only one battery.

(d) Magneto ground wiring (for separate ignition circuits) that lies on the engine side of any firewall must be installed, located, or protected to minimize the probability of the simultaneous failure of two or more wires as a result of mechanical damage, electrical fault, or other cause.

(e) No ground wire for any engine may be routed through a fire zone of another engine unless each part of that wire within that zone is fireproof.

(f) Each ignition system must be independent of any electrical circuit that is not used for assisting, controlling, or analyzing the operation of that system.

(g) There must be means to warn appropriate crewmembers if the malfunctioning of any part of the electrical system is causing the continuous discharge of any battery necessary for engine ignition.

[(Amdt. 29–12, Eff. 2/1/77)]

## POWERPLANT FIRE PROTECTION

### § 29.1181 Designated fire zones: Regions included.

(a) Designated fire zones are—

(1) The engine power section of reciprocating engines;

(2) The engine accessory section of reciprocating engines;

(3) Any complete powerplant compartment in which there is no isolation between the engine power section and the engine accessory section, for reciprocating engines;

(4) Any auxiliary power unit compartment;

(5) Any fuel-burning heater and other combustion equipment installation described in § 29.859;

(6) The compressor and accessory sections of turbine engines; and

(7) The combustor, turbine, and tailpipe sections of turbine engine installations except sections that do not contain lines and components carrying flammable fluids or gases and are isolated from the designated fire zone prescribed in paragraph (a)(6) of this section by a firewall that meets § 29.1191.

(b) Each designated fire zone must meet the requirements of §§ 29.1183 through 29.1203.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1183 Lines, fittings, and components.

(a) Except as provided in paragraph (b) of this section, each line, fitting, and other component carrying flammable fluid in any area subject to engine fire conditions and each component which conveys or contains flammable fluid in a designated fire zone must be fire resistant, except that flammable fluid tanks and supports in a designated fire zone must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 25-quart capacity on a reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Paragraph (a) of this section does not apply to—

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in or add to, a fire hazard.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–22, Eff. 3/26/84)]

### § 29.1185 Flammable fluids.

(a) No tank or reservoir that is part of a system containing flammable fluids or gases may be in a designated fire zone unless the fluid contained, the design of the system, the materials used in the tank and its supports, the shutoff means, and the connections, lines, and controls provide a degree of safety equal to that which would exist if the tank or reservoir were outside such a zone.

(b) Each fuel tank must be isolated from the engines by a firewall or shroud.

(c) There must be at least one-half inch of clear airspace between each tank or reservoir and each firewall or shroud isolating a designated fire zone, unless equivalent means are used to prevent heat transfer from the fire zone to the flammable fluid.

(d) Absorbent materials close to flammable fluid system components that might leak must be covered or treated to prevent the absorption of hazardous quantities of fluids.

### § 29.1187 Drainage and ventilation of fire zones.

(a) There must be complete drainage of each part of each designated fire zone to minimize the hazards resulting from failure or malfunction of any component containing flammable fluids. The drainage means must be—

(1) Effective under conditions expected to prevail when drainage is needed; and

(2) Arranged so that no discharged fluid will cause an additional fire hazard.

(b) Each designated fire zone must be ventilated to prevent the accumulation of flammable vapors.

(c) No ventilation opening may be where it would allow the entry of flammable fluids, vapors, or flame from other zones.

(d) Ventilation means must be arranged so that no discharged vapors will cause an additional fire hazard.

(e) For category A rotorcraft, there must be means to allow the crew to shut off the sources of forced ventilation in any fire zone (other than the engine power section of the powerplant compartment) unless the amount of extinguishing agent and the rate of discharge are based on the maximum airflow through that zone.

### § 29.1189 Shutoff means.

(a) There must be means to shut off or otherwise prevent hazardous quantities of fuel, oil, de-icing fluid, and other flammable fluids from flowing into, within, or through any designated fire zone, except that this means need not be provided—

(1) For lines, fittings, and components forming an integral part of an engine;

(2) For oil systems for turbine engine installations in which all components of the oil system, including oil tanks, are fireproof or located in areas not subject to engine fire conditions; or

(3) For engine oil systems in category B rotorcraft using reciprocating engines of less than 500 cubic inches displacement.

(b) The closing of any fuel shutoff valve for any engine may not make fuel unavailable to the remaining engines.

(c) For category A rotorcraft, no hazardous quantity of flammable fluid may drain into any designated fire zone after shutoff has been accomplished, nor may the closing of any fuel shutoff valve for an engine make fuel unavailable to the remaining engines.

(d) The operation of any shutoff may not interfere with the later emergency operation of any other equipment, such as the means for declutching the engine from the rotor drive.

(e) Each shutoff valve and its control must be designed, located, and protected to function properly under any condition likely to result from fire in a designated fire zone.

(f) Except for ground-use-only auxiliary power unit installations, there must be means to prevent inadvertent operation of each shutoff and to make it possible to reopen it in flight after it has been closed.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–22, Eff. 3/26/84)]

### § 29.1191 Firewalls.

(a) Each engine, including the combustor, turbine, and tailpipe sections of turbine engine installations, must be isolated by a firewall, shroud, or equivalent means, from personnel compartments, structures, controls, rotor mechanisms, and other parts that are—

(1) Essential to controlled flight and landing; and

(2) Not protected under § 29.861.

(b) Each auxiliary power unit, combustion heater, and other combustion equipment to be used in flight, must be isolated from the rest of the rotorcraft by firewalls, shrouds, or equivalent means.

(c) Each firewall or shroud must be constructed so that no hazardous quantity of air, fluid, or flame can pass from any engine compartment to other parts of the rotorcraft.

(d) Each opening in the firewall or shroud must be sealed with close-fitting fireproof grommets, bushings, or firewall fittings.

(e) Each firewall and shroud must be fireproof and protected against corrosion.

(f) In meeting this section, account must be taken of the probable path of a fire as affected by the airflow in normal flight and in autorotation.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.1193 Cowling and engine compartment covering.

(a) Each cowling and engine compartment covering must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

(b) Cowling must meet the drainage and ventilation requirements of § 29.1187.

(c) On rotorcraft with a diaphragm isolating the engine power section from the engine accessory section, each part of the accessory section cowling subject to flame in case of fire in the engine power section of the powerplant must—

(1) Be fireproof; and

(2) Meet the requirements of § 29.1191.

(d) Each part of the cowling or engine compartment covering subject to high temperatures due to its nearness to exhaust system parts or exhaust gas impingement must be fireproof.

(e) Each rotorcraft must—

(1) Be designed and constructed so that no fire originating in any fire zone can enter, either through openings or by burning through external skin, any other zone or region where it would create additional hazards;

(2) Meet the requirements of paragraph (e)(1) of this section with the landing gear retracted (if applicable); and

(3) Have fireproof skin in areas subject to flame if a fire starts in or burns out of any designated fire zone.

(f) A means of retention for each openable or readily removable panel, cowling, or engine or rotor drive system covering must be provided to preclude hazardous damage to rotors or critical control components in the event of—

(1) Structural or mechanical failure of the normal retention means, unless such failure is extremely improbable; or

(2) Fire in a fire zone, if such fire could adversely affect the normal means of retention.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1194 Other surfaces.

All surfaces aft of, and near, engine compartments and designated fire zones, other than tail surfaces not subject to heat flames, or sparks emanating from a designated fire zone or engine compartment, must be at least fire resistant.

[(Amdt. 29–3, Eff. 2/25/68)]

### § 29.1195 Fire extinguishing systems.

(a) Each turbine engine powered rotorcraft and Category A reciprocating engine powered rotorcraft, and each Category B reciprocating engine powered rotorcraft with engines of more than 1,500 cubic inches must have a fire extinguishing system for the designated fire zones. The fire extinguishing system for a powerplant must be able to simultaneously protect all zones of the powerplant compartment for which protection is provided.

(b) For multiengine powered rotorcraft, the fire extinguishing system, the quantity of extinguishing agent, and the rate of discharge must—

(1) For each auxiliary power unit and combustion equipment, provide at least one adequate discharge; and

(2) For each other designated fire zone, provide two adequate discharges.

(c) For single engine rotorcraft, the quantity of extinguishing agent and the rate of discharge must provide at least one adequate discharge for the engine compartment.

(d) It must be shown by either actual or simulated flight tests that under critical airflow conditions in flight the discharge of the extinguishing agent in each designated fire zone will provide an agent concentration capable of extinguishing fires in that zone and of minimizing the probability of reignition.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–17, Eff. 12/1/78)]

### § 29.1197 Fire extinguishing agents.

(a) Fire extinguishing agents must—

(1) Be capable of extinguishing flames emanating from any burning of fluids or other combus-

tible materials in the area protected by the fire extinguishing system; and

(2) Have thermal stability over the temperature range likely to be experienced in the compartment in which they are stored.

(b) If any toxic extinguishing agent is used it must be shown by test that entry of harmful concentrations of fluid or fluid vapors into any personnel compartment (due to leakage during normal operation of the rotorcraft, or discharge on the ground or in flight) is prevented, even though a defect may exist in the extinguishing system.

(c) [Deleted]

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–13, Eff. 5/2/77)]

### § 29.1199 Extinguishing agent containers.

(a) Each extinguishing agent container must have a pressure relief to prevent bursting of the container by excessive internal pressures.

(b) The discharge end of each discharge line from a pressure relief connection must be located so that discharge of the fire extinguishing agent would not damage the rotorcraft. The line must also be located or protected to prevent clogging caused by ice or other foreign matter.

(c) There must be a means for each fire extinguishing agent container to indicate that the container has discharged or that the charging pressure is below the established minimum necessary for proper functioning.

(d) The temperature of each container must be maintained, under intended operating conditions, to prevent the pressure in the container from—

(1) Falling below that necessary to provide an adequate rate of discharge; or

(2) Rising high enough to cause premature discharge.

[(Amdt. 29–13, Eff. 5/2/77)]

### § 29.1201 Fire extinguishing system materials.

(a) No materials in any fire extinguishing system may react chemically with any extinguishing agent so as to create a hazard.

(b) Each system component in an engine compartment must be fireproof.

### § 29.1203 Fire detector systems.

(a) For each turbine engine powered rotorcraft and category A reciprocating engine powered rotorcraft, and for each category B reciprocating engine powered rotorcraft with engines of more than 900 cubic inches displacement, there must be approved, quick-acting fire detectors in designated fire zones and in the combustor, turbine, and tailpipe sections of turbine installations (whether or not such sections are designated fire zones) in numbers and locations ensuring prompt detection of fire in those zones.

(b) Each fire detector must be constructed and installed to withstand any vibration, inertia, and other loads to which it would be subjected in operation.

(c) No fire detector may be affected by any oil, water, other fluids, or fumes that might be present.

(d) There must be means to allow crewmembers to check, in flight, the functioning of each fire detector system electrical circuit.

(e) The wiring and other components of each fire detector system in an engine compartment must be at least fire resistant.

(f) No fire detector system component for any fire zone may pass through another fire zone, unless—

(1) It is protected against the possibility of false warnings resulting from fires in zones through which it passes; or

(2) The zones involved are simultaneously protected by the same detector and extinguishing systems.

[(Amdt. 29–3, Eff. 2/25/68)]

# Subpart F—Equipment

## GENERAL

### § 29.1301 Function and installation.

Each item of installed equipment must—

(a) Be of a kind and design appropriate to its intended function;

(b) Be labeled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(c) Be installed according to limitations specified for that equipment; and

(d) Function properly when installed.

### § 29.1303 Flight and navigation instruments.

The following are required flight and navigational instruments:

(a) An airspeed indicator. For Category A rotorcraft with $V_{NE}$ less than a speed at which unmistakable pilot cues provide overspeed warning, a maximum allowable airspeed indicator must be provided. If maximum allowable airspeed varies with weight, altitude, temperature, or r.p.m., the indicator must show that variation.

(b) A sensitive altimeter.

(c) A magnetic direction indicator.

(d) A clock displaying hours, minutes, and seconds with a sweep-second pointer or digital presentation.

(e) A free-air temperature indicator.

(f) A non-tumbling gyroscopic bank and pitch indicator.

(g) A gyroscopic rate-of-turn indicator combined with an integral slip-skid indicator (turn-and-bank indicator) except only a slip-skid indicator is required on rotorcraft with a third attitude instrument system that—

(1) Is usable through flight attitudes of ±80 degrees of pitch and ±120 degrees of roll;

(2) Is powered from a source independent of the electrical generating system;

(3) Continues reliable operation for a minimum of 30 minutes after total failure of the electrical generating system;

(4) Operates independently of any other attitude indicating system;

(5) Is operative without selection after total failure of the electrical generating system;

(6) Is located on the instrument panel in a position acceptable to the Administrator that will make it plainly visible to and usable by any pilot at his station; and

(7) Is appropriately lighted during all phases of operation.

(h) A gyroscopic direction indicator.

(i) A rate-of-climb (vertical speed) indicator.

(j) For Category A rotorcraft, a speed warning device when $V_{NE}$ is less than the speed at which unmistakable overspeed warning is provided by other pilot cues. The speed warning device must give effective aural warning (differing distinctively from aural warnings used for other purposes) to the pilots whenever the indicated speed exceeds $V_{NE}$ plus 3 knots and must operate satisfactorily throughout the approved range of altitudes and temperatures.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–14, Eff. 9/1/77); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1305 Powerplant instruments.

The following are required powerplant instruments:

(a) For each rotorcraft—

(1) A carburetor air temperature indicator for each reciprocating engine;

(2) A cylinder head temperature indicator for each air-cooled reciprocating engine, and a coolant temperature indicator for each liquid-cooled reciprocating engine;

(3) A fuel quantity indicator for each fuel tank;

(4) A low fuel warning device for each fuel tank which feeds an engine. This device must—

(i) Provide a warning to the crew when approximately 10 minutes of usable fuel remains in the tank; and

(ii) Be independent of the normal fuel quantity indicating system.

(5) A manifold pressure indicator, for each reciprocating engine of the altitude type;

[(6) An oil pressure indicator for each pressure-lubricated gearbox.]

([7]) An oil pressure warning device for each pressure-lubricated gearbox to indicate when the oil pressure falls below a safe value;

([8]) An oil quantity indicator for each oil tank and each rotor drive gearbox, if lubricant is self-contained;

([9]) An oil temperature indicator for each engine;

([10]) An oil temperature warning device to indicate unsafe oil temperatures in each main rotor drive gearbox, including gearboxes necessary for rotor phasing;

([11]) A gas temperature indicator for each turbine engine;

([12]) A gas producer rotor tachometer for each turbine engine;

([13]) A tachometer for each engine that, if combined with the applicable instrument required by paragraph (a)([14]) of this section, indicates rotor r.p.m. during autorotation.

([14]) At least one tachometer to indicate, as applicable—

(i) The r.p.m. of single main rotor;

(ii) The common r.p.m. of any main rotors whose speeds cannot vary appreciably with respect to each other; and

(iii) The r.p.m. of each main rotor whose speed can vary appreciably with respect to that of another main rotor;

([15]) A free power turbine tachometer for each turbine engine;

([16]) A means, for each turbine engine, to indicate power for that engine;

([17]) For each turbine engine, an indicator to indicate the functioning of the powerplant ice protection system;

([18]) An indicator for the filter required by § 29.997 to indicate the occurrence of contamination of the filter to the degree established in compliance with § 29.955;

([19]) For each turbine engine, a warning means for the oil strainer or filter required by § 29.1019, if it has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with § 29.1019(a)(2);

([20]) An indicator to indicate the functioning of any selectable or controllable heater used to prevent ice clogging of fuel system components;

([21]) An individual fuel pressure indicator for each engine, unless the fuel system which supplies that engine does not employ any pumps, filters, or other components subject to degradation or failure which may adversely affect fuel pressure at the engine;

([22]) A means to indicate to the flightcrew the failure of any fuel pump installed to show compliance with § 29.955;

([23]) Warning or caution devices to signal to the flightcrew when ferromagnetic particles are detected by the chip detector required by § 29.1337(e); and

([24]) For auxiliary power units, an individual indicator, warning or caution device, or other means to advise the flightcrew that limits are being exceeded, if exceeding these limits can be hazardous, for—

(i) Gas temperature;

(ii) Oil pressure; and

(iii) Rotor speed.

([25]) For rotorcraft for which a 30-second/2-minute OEI power rating is requested, a means must be provided to alert the pilot when the engine is at the 30-second and 2-minute OEI power levels, when the event begins, and when the time interval expires.

([26]) For each turbine engine utilizing 30-second/2-minute OEI power, a device or system must be provided for use by ground personnel which—

(i) Automatically records each usage and duration of power at the 30-second and 2-minute OEI levels;

(ii) Permits retrieval of the recorded data;

(iii) Can be reset only by ground maintenance personnel; and

(iv) Has a means to verify proper operation of the system or device.

(b) For category A rotorcraft—

(1) An individual oil pressure indicator for each engine, and either an independent warning device for each engine or a master warning device for the engines with means for isolating the individual warning circuit from the master warning device;

(2) An independent fuel pressure warning device for each engine or a master warning device for all engines with provision for isolating the individual warning device from the master warning device; and

(3) Fire warning indicators.

(c) For category B rotorcraft—

(1) An individual oil pressure indicator for each engine; and

2) Fire warning indicators, when fire detection is required.

(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–10, Eff. 10/31/74); (Amdt. 29–26, Eff. 10/3/88); (Amdt. 29–34, Eff. 10/17/94); [(Amdt. 29–40, Eff. 8/8/96)]

### § 29.1307 Miscellaneous equipment.

The following is required miscellaneous equipment:

(a) An approved seat for each occupant.

(b) A master switch arrangement for electrical circuits other than ignition.

(c) Hand fire extinguishers.

(d) A windshield wiper or equivalent device for each pilot station.

(e) A two-way radio communication system.

[(Amdt. 29–12, Eff. 2/1/77)]

### § 29.1309 Equipment, systems, and installations.

(a) The equipment, systems, and installations whose functioning is required by this subchapter must be designed and installed to ensure that they perform their intended functions under any forseeable operating condition.

(b) The rotorcraft systems and associated components, considered separately and in relation to other systems, must be designed so that—

(1) For Category B rotorcraft, the equipment, systems, and installations must be designed to prevent hazards to the rotorcraft if they malfunction or fail; or

(2) For Category A rotorcraft—

(i) The occurrence of any failure condition which would prevent the continued safe flight and landing of the rotorcraft is extremely improbable; and

(ii) The occurrence of any other failure conditions which would reduce the capability of the rotorcraft or the ability of the crew to cope with adverse operating conditions is improbable.

(c) Warning information must be provided to alert the crew to unsafe system operating conditions and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors which could create additional hazards.

(d) Compliance with the requirements of paragraph (b)(2) of this section must be shown by analysis and, where necessary, by appropriate ground, flight, or simulator tests. The analysis must consider—

(1) Possible modes of failure, including malfunctions and damage from external sources;

(2) The probability of multiple failures and undetected failures;

(3) The resulting effects on the rotorcraft and occupants, considering the stage of flight and operating conditions; and

(4) The crew warning cues, corrective action required, and the capability of detecting faults.

(e) For Category A rotorcraft, each installation whose functioning is required by this subchapter and which requires a power supply is an "essential load" on the power supply. The power sources and the system must be able to supply the following power loads in probable operating combinations and for probable durations:

(1) Loads connected to the system with the system functioning normally.

(2) Essential loads, after failure of any one prime mover, power converter, or energy storage device.

(3) Essential loads, after failure of—

(i) Any one engine, on rotorcraft with two engines; and

(ii) Any two engines, on rotorcraft with three or more engines.

(f) In determining compliance with paragraphs (e)(2) and (3) of this section, the power loads may be assumed to be reduced under a monitoring procedure consistent with safety in the kinds of operations authorized. Loads not required for controlled flight need not be considered for the two-engine-inoperative condition on rotorcraft with three or more engines.

(g) In showing compliance with paragraphs (a) and (b) of this section with regard to the electrical system and to equipment design and installation, critical environmental conditions must be considered. For electrical generation, distribution, and utilization equipment required by or used in complying with this subchapter, except equipment covered by Technical Standard Orders containing environmental test procedures, the ability to provide continuous, safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis, or reference to previous comparable service experience on other aircraft.

(h) [In showing compliance with paragraphs (a) and (b) of this section, the effects of lightning strikes on the rotorcraft must be considered.]

(Amdt. 29–14, Eff. 9/1/77); (Amdt. 29–24, Eff. 12/6/84); [(Amdt. 29–40, Eff. 8/8/96)]

## INSTRUMENTS INSTALLATION

### § 29.1321 Arrangement and visibility.

(a) Each flight, navigation, and powerplant instrument for use by any pilot must be easily visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path.

(b) Each instrument necessary for safe operation, including the airspeed indicator, gyroscopic direction indicator, gyroscopic bank-and-pitch indicator, slip-skid indicator, altimeter, rate-of-climb indicator, rotor tachometers, and the indicator most representative of engine power, must be grouped and centered as nearly as practicable about the vertical plane of the pilot's forward vision. In addition, for rotorcraft approved for IFR flight—

(1) The instrument that most effectively indicates attitude must be on the panel in the top center position;

(2) The instrument that most effectively indicates direction of flight must be adjacent to and directly below the attitude instrument;

(3) The instrument that most effectively indicates airspeed must be adjacent to and to the left of the attitude instrument; and

(4) The instrument that most effectively indicates altitude or is most frequently utilized in control of altitude must be adjacent to and to the right of the attitude instrument.

(c) Other required powerplant instruments must be closely grouped on the instrument panel.

(d) Identical powerplant instruments for the engines must be located so as to prevent any confusion as to which engine each instrument relates.

(e) Each powerplant instrument vital to safe operation must be plainly visible to appropriate crewmembers.

(f) Instrument panel vibration may not damage, or impair the readability or accuracy of, any instrument.

(g) If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.

[(Amdt. 29–14, Eff. 9/1/77); (Amdt. 29–21, Eff. 3/2/83) ]

### § 29.1322 Warning, caution, and advisory lights.

If warning, caution or advisory lights are installed in the cockpit they must, unless otherwise approved by the Administrator, be—

(a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action);

(b) Amber, for caution lights (lights indicating the possible need for future corrective action);

(c) Green, for safe operation lights; and

(d) Any other color, including white, for lights not described in paragraphs (a) through (c) of this section, provided the color differs sufficiently from the colors prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77)]

### § 29.1323 Airspeed indicating system.

For each airspeed indicating system, the following apply:

(a) Each airspeed indicating instrument must be calibrated to indicate true airspeed (at sea level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pilot and static pressures are applied.

(b) Each system must be calibrated to determine system error excluding airspeed instrument error. This calibration must be determined—

(1) In level flight at speeds of 20 knots and greater, and over an appropriate range of speeds for flight conditions of climb and autorotation; and

(2) During takeoff, with repeatable and readable indications that ensure—

(i) Consistent realization of the field lengths specified in the Rotorcraft Flight Manual; and

(ii) [Avoidance of the critical areas of the height-velocity envelope as established under § 29.87.]

(c) For Category A rotorcraft—

(1) The indication must allow consistent definition of the critical decision point; and

(2) The system error, excluding the airspeed instrument calibration error, may not exceed—

(i) Three percent or 5 knots, whichever is greater, in level flight at speeds above 80 percent of takeoff safety speed; and

(ii) Ten knots in climb at speeds from 10 knots below takeoff safety speed to 10 knots above $V_Y$.

(d) For Category B rotorcraft, the system error, excluding the airspeed instrument calibration error, may not exceed 3 percent or 5 knots, whichever is greater, in level flight at speeds above 80 percent of the climb out speed attained at 50 feet when complying with § 29.63.

(e) Each system must be arranged, so far as practicable, to prevent malfunction or serious error due to the entry of moisture, dirt, or other substances.

(f) Each system must have a heated pilot tube or an equivalent means of preventing malfunction due to icing.

(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–24, Eff. 12/6/84); [(Amdt. 29–39, Eff. 6/10/96)]

## § 29.1325 Static pressure and pressure altimeter systems.

(a) Each instrument with static air case connections must be vented to the outside atmosphere through an appropriate piping system.

(b) Each vent must be located where its orifices are least affected by airflow variation, moisture, or foreign matter.

(c) Each static pressure port must be designed and located in such manner that the correlation between air pressure in the static pressure system and true ambient atmospheric static pressure is not altered when the rotorcraft encounters icing conditions. An anti-icing means or an alternate source of static pressure may be used in showing compliance with this requirement. If the reading of the altimeter, when on the alternate static pressure system, differs from the reading of the altimeter when on the primary static system by more than 50 feet, a correction card must be provided for the alternate static system.

(d) Except for the vent into the atmosphere, each system must be airtight.

(e) Each pressure altimeter must be approved and calibrated to indicate pressure altitude in a standard atmosphere with a minimum practicable calibration error when the corresponding static pressures are applied.

(f) Each system must be designed and installed so that an error in indicated pressure altitude, at sea level, with a standard atmosphere, excluding instrument calibration error, does not result in an error of more than ± 30 feet per 100 knots speed. However, the error need not be less than ± 30 feet.

(g) Except as provided in paragraph (h) of this section, if the static pressure system incorporates both a primary and an alternate static pressure source, the means for selecting one or the other source must be designed so that—

(1) When either source is selected, the other is blocked off; and

(2) Both sources cannot be blocked off simultaneously.

(h) For unpressurized rotorcraft, paragraph (g)(1) of this section does not apply if it can be demonstrated that the static pressure system calibration, when either static pressure source is selected, is not changed by the other static pressure source being open or blocked.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–14, Eff. 9/1/77); (Amdt. 29–24, Eff. 12/6/84)]

## § 29.1327 Magnetic direction indicator.

(a) Each magnetic direction indicator must be installed so that its accuracy is not excessively affected by the rotorcraft's vibration or magnetic fields.

(b) The compensated installation may not have a deviation, in level flight, greater than 10° on any heading.

## § 29.1329 Automatic pilot system.

(a) Each automatic pilot system must be designed so that the automatic pilot can—

(1) Be sufficiently overpowered by one pilot to allow control of the rotorcraft; and

(2) Be readily and positively disengaged by each pilot to prevent it from interfering with the control of the rotorcraft.

(b) Unless there is automatic synchronization, each system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates.

(c) Each manually operated control for the system's operation must be readily accessible to the pilots.

(d) The system must be designed and adjusted so that, within the range of adjustment available to the pilot, it cannot produce hazardous loads on the rotorcraft, or create hazardous deviations in the flight path, under any flight condition appropriate to its use, either during normal operation or in the event of a malfunction, assuming that corrective action begins within a reasonable period of time.

(e) If the automatic pilot integrates signals from auxiliary controls or furnishes signals for operation of other equipment, there must be positive interlocks and sequencing of engagement to prevent improper operation.

[(Amdt. 29–24, Eff. 12/6/84)]

## § 29.1331 Instruments using a power supply.

For category A rotorcraft—

(a) Each required flight instrument using a power supply must have—

(1) Two independent sources of power;

(2) A means of selecting either power source; and

(3) A visual means integral with each instrument to indicate when the power adequate to sustain proper instrument performance is not being supplied. The power must be measured at or near the point where it enters the instrument. For electrical instruments, the power is considered to be adequate when the voltage is within the approved limits; and

(b) The installation and power supply system must be such that failure of any flight instrument connected to one source, or of the energy supply from one source, or a fault in any part of the power distribution system does not interfere with the proper supply of energy from any other source. [(Amdt. 29–24, Eff. 12/6/84)]

### § 29.1333 Instrument systems.

For systems that operate the required flight instruments which are located at each pilot's station, the following apply:

(a) Only the required flight instruments for the first pilot may be connected to that operating system.

(b) The equipment, systems, and installations must be designed so that one display of the information essential to the safety of flight which is provided by the flight instruments remains available to a pilot, without additional crewmember action, after any single failure or combination of failures that are not shown to be extremely improbable.

(c) Additional instruments, systems, or equipment may not be connected to the operating system for a second pilot unless provisions are made to ensure the continued normal functioning of the required flight instruments in the event of any malfunction of the additional instruments, systems, or equipment which is not shown to be extremely improbable. [(Amdt. 29–24, Eff. 12/6/84)]

### § 29.1335 Flight director systems.

If a flight director system is installed, means must be provided to indicate to the flight crew its current mode of operation. Selector switch position is not acceptable as a means of indication. [(Amdt. 29–14, Eff. 9/1/77)]

### § 29.1337 Powerplant instruments.

(a) *Instruments and instrument lines.*

(1) Each powerplant and auxiliary power unit instrument line must meet the requirements of §§ 29.993 and 29.1183.

(2) Each line carrying flammable fluids under pressure must—

(i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and

(ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each powerplant and auxiliary power unit instrument that utilizes flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) *Fuel quantity indicator.* There must be means to indicate to the flight crewmembers the quantity, in gallons or equivalent units, of usable fuel in each tank during flight. In addition—

(1) Each fuel quantity indicator must be calibrated to read "zero" during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under § 29.959;

(2) When two or more tanks are closely interconnected by a gravity feed system and vented, and when it is impossible to feed from each tank separately, at least one fuel quantity indicator must be installed;

(3) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators; and

(4) Each exposed sight gauge used as a fuel quantity indicator must be protected against damage.

(c) *Fuel flowmeter system.* If a fuel flowmeter system is installed, each metering component must have a means for bypassing the fuel supply if malfunction of that component severely restricts fuel flow.

(d) *Oil quantity indicator.* There must be a stick gauge or equivalent means to indicate the quantity of oil—

(1) In each tank, and

(2) In each transmission gearbox.

(e) Rotor drive system transmissions and gearboxes utilizing ferromagnetic materials must be equipped with chip detectors designed to indicate the presence of ferromagnetic particles resulting from damage or excessive wear within the transmission or gearbox. Each chip detector must—

(1) Be designed to provide a signal to the indicator required by § 29.1305(a)(22); and

(2) Be provided with a means to allow crewmembers to check, in flight, the function of each detector electrical circuit and signal.

[(Amdt. 29–13, Eff. 5/2/77); (Amdt. 29–26, Eff. 10/3/88)]

## ELECTRICAL SYSTEMS AND EQUIPMENT

### § 29.1351 General.

(a) *Electrical system capacity.* The required generating capacity and the number and kind of power sources must—

(1) Be determined by an electrical load analysis; and

(2) Meet the requirements of § 29.1309.

(b) *Generating system.* The generating system includes electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices. It must be designed to that—

(1) Power sources function properly when independent and when connected in combination;

(2) No failure or malfunction of any power source can create a hazard or impair the ability of remaining sources to supply essential loads;

(3) The system voltage and frequency (as applicable) at the terminals of essential load equipment can be maintained within the limits for which the equipment is designed, during any probable operating condition;

(4) System transients due to switching, fault clearing, or other causes do not make essential loads inoperative, and do not cause a smoke or fire hazard;

(5) There are means accessible in flight to appropriate crewmembers for the individual and collective disconnection of the electrical power sources from the main bus; and

(6) There are means to indicate to appropriate crewmembers the generating system quantities essential for the safe operation of the system, such as the voltage and current supplied by each generator.

(c) *External power.* If provisions are made for connecting external power to the rotorcraft, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or a reverse phase sequence, can supply power to the rotorcraft's electrical system.

(d) [*Operation with the normal electrical power generating system inoperative.*

[(1) It must be shown by analysis, tests, or both, that the rotorcraft can be operated safely in VFR conditions for a period of not less than 5 minutes, with the normal electrical power generating system (electrical power sources excluding the battery) inoperative, with critical type fuel (from the standpoint of flameout and restart capability), and with the rotorcraft initially at the maximum certificated altitude. Parts of the electrical system may remain on if—

[(i) A single malfunction, including a wire bundle or junction box fire, cannot result in loss of the part turned off and the part turned on;

[(ii) The parts turned on are electrically and mechanically isolated from the parts turned off; and

[(iii) The electrical wire and cable insulation, and other materials, of the parts turned on are self-extinguishing when tested in accordance with § 25.1359(d) in effect on September 1, 1977.

[(2) Additional requirements for Category A Rotorcraft.

[(i) Unless it can be shown that the loss of the normal electrical power generating system is extremely improbable, an emergency electrical power system, independent of the normal electrical power generating system, must be provided, with sufficient capacity to power all systems necessary for continued safe flight and landing.

[(ii) Failures, including junction box, control panel, or wire bundle fires, which would result in the loss of the normal and emergency systems, must be shown to be extremely improbable.

[(iii) Systems necessary for immediate safety must continue to operate following the loss of the normal electrical power generating system, without the need for flight crew action.]

(Amdt. 29–14, Eff. 9/1/77); [(Amdt. 29–40, Eff. 8/8/96)]

### § 29.1353 Electrical equipment and installations.

(a) Electrical equipment, controls, and wiring must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other electrical unit or system essential to safe operation.

(b) Cables must be grouped, routed, and spaced so that damage to essential circuits will be minimized if there are faults in heavy current-carrying cables.

(c) Storage batteries must be designed and installed as follows:

(1) Safe cell temperatures and pressures must be maintained during any probable charging and discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge)—

(i) At maximum regulated voltage or power;

(ii) During a flight of maximum duration; and

(iii) Under the most adverse cooling condition likely in service.

(2) Compliance with paragraph (a)(1) of this section must be shown by test unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem.

(3) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the rotorcraft.

(4) No corrosive fluids or gases that may escape from the battery may damage surrounding structures or adjacent essential equipment.

(5) Each nickel cadmium battery installation capable of being used to start an engine or auxiliary power unit must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(6) Nickel cadmium battery installations capable of being used to start an engine or auxiliary power unit must have—

(i) A system to control the charging rate of the battery automatically so as to prevent battery overheating;

(ii) A battery temperature sensing and over-temperature warning system with a means for disconnecting the battery from its charging source in the event of an over-temperature condition; or

(iii) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

[(Amdt. 29–14, Eff. 9/1/77); (Amdt. 29–15, Eff. 3/1/78)]

### § 29.1355 Distribution system.

(a) The distribution system includes the distribution busses, their associated feeders, and each control and protective device.

(b) If two independent sources of electrical power for particular equipment or systems are required by this chapter, in the event of the failure of one power source for such equipment or system, another power source (including its separate feeder) must be provided automatically or be manually selectable to maintain equipment or system operation.

[(Amdt. 29–14, Eff. 9/1/77); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1357 Circuit protective devices.

(a) Automatic protective devices must be used to minimize distress to the electrical system and hazard to the rotorcraft in the event of wiring faults or serious malfunction of the system or connected equipment.

(b) The protective and control devices in the generating system must be designed to de-energize and disconnect faulty power sources and power transmission equipment from their associated buses with sufficient rapidity to provide protection from hazardous overvoltage and other malfunctioning.

(c) Each resettable circuit protective device must be designed so that, when an overload or circuit fault exists, it will open the circuit regardless of the position of the operating control.

(d) If the ability to reset a circuit breaker or replace a fuse is essential to safety in flight, that circuit breaker or fuse must be located and identified so that it can be readily reset or replaced in flight.

(e) Each essential load must have individual circuit protection. However, individual protection for each circuit in an essential load system (such as each position light circuit in a system) is not required.

(f) If fuses are used, there must be spare fuses for use in flight equal to at least 50 percent of the number of fuses of each rating required for complete circuit protection.

(g) Automatic reset circuit breakers may be used as integral protectors for electrical equipment provided there is circuit protection for the cable supplying power to the equipment.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.1359 Electrical system fire and smoke protection.

(a) Components of the electrical system must meet the applicable fire and smoke protection provisions of §§ 29.831 and 29.863.

(b) Electrical cables, terminals, and equipment, in designated fire zones, and that are used in emergency procedures, must be at least fire resistant.

### § 29.1363 Electrical system tests.

(a) When laboratory tests of the electrical system are conducted—

(1) The tests must be performed on a mock-up using the same generating equipment used in the rotorcraft;

(2) The equipment must simulate the electrical characteristics of the distribution wiring and connected loads to the extent necessary for valid test results; and

(3) Laboratory generator drives must simulate the prime movers on the rotorcraft with respect to their reaction to generator loading, including loading due to faults.

(b) For each flight condition that cannot be simulated adequately in the laboratory or by ground tests on the rotorcraft, flight tests must be made.

## LIGHTS

### § 29.1381 Instrument lights.

The instrument lights must—

(a) Make each instrument, switch, and other device for which they are provided easily readable; and

(b) Be installed so that—

(1) Their direct rays are shielded from the pilot's eyes; and

(2) No objectionable reflections are visible to the pilot.

### § 29.1383 Landing lights.

(a) Each required landing or hovering light must be approved.

(b) Each landing light must be installed so that—

(1) No objectionable glare is visible to the pilot;

(2) The pilot is not adversely affected by halation; and

(3) It provides enough light for night operation, including hovering and landing.

(c) At least one separate switch must be provided, as applicable—

(1) For each separately installed landing light; and

(2) For each group of landing lights installed at a common location.

### § 29.1385 Position light system installation.

(a) *General.* Each part of each position light system must meet the applicable requirements of this section and each system as a whole must meet the requirements of §§ 29.1387 through 29.1397.

(b) *Forward position lights.* Forward position lights must consist of a red and a green light spaced laterally as far apart as practicable and installed forward on the rotorcraft so that, with the rotorcraft in the normal flying position, the red light is on the left side, and the green light is on the right side. Each light must be approved.

(c) *Rear position light.* The rear position light must be a white light mounted as far aft as practicable, and must be approved.

(d) *Circuit.* The two forward position lights and the rear position light must make a single circuit.

(e) *Light covers and color filters.* Each light cover or color filter must be at least flame resistant and may not change color or shape or lose any appreciable light transmission during normal use.

### § 29.1387 Position light system dihedral angles.

(a) Except as provided in paragraph (e) of this section, each forward and rear position light must, as installed, show unbroken light within the dihedral angles described in this section.

(b) Dihedral angle *L* (left) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the rotorcraft, and the other at 110 degrees to the left of the first, as viewed when looking forward along the longitudinal axis.

(c) Dihedral angle *R* (right) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the rotorcraft, and the other at 110 degrees to the right of the first, as viewed when looking forward along the longitudinal axis.

(d) Dihedral angle *A* (aft) is formed by two intersecting vertical planes making angles of 70 degrees to the right and to the left, respectively, to a vertical plane passing through the longitudinal axis, as viewed when looking aft along the longitudinal axis.

(e) If the rear position light, when mounted as far aft as practicable in accordance with § 29.1385(c), cannot show unbroken light within dihedral angle *A* (as defined in paragraph (d) of this section), a solid angle or angles of obstructed visibility totaling not more than 0.04 steradians is allowable within that dihedral angle, if such solid angle is within a cone whose apex is at the rear position light and whose elements make an angle of 30° with a vertical line passing through the rear position light.

[(Amdt. 29–9, Eff. 11/5/71)]

### § 29.1389 Position light distribution and intensities.

(a) *General.* The intensities prescribed in this section must be provided by new equipment with light covers and color filters in place. Intensities must be determined with the light source operating at a steady value equal to the average luminous output of the source at the normal operating voltage of the rotorcraft. The light distribution and intensity of each position light must meet the requirements of paragraph (b) of this section.

(b) *Forward and rear position lights.* The light distribution and intensities of forward and rear position lights must be expressed in terms of minimum intensities in the horizontal plane, minimum intensities in any vertical plane, and maximum intensities in overlapping beams, within dihedral angles, *L, R,* and *A,* and must meet the following requirements:

(1) *Intensities in the horizontal plane.* Each intensity in the horizontal plane (the plane containing the longitudinal axis of the rotorcraft and perpendicular to the plane of symmetry of the rotorcraft), must equal or exceed the values in § 29.1391.

(2) *Intensities in any vertical plane.* Each intensity in any vertical plane (the plane perpendicular to the horizontal plane) must equal or exceed the appropriate value in § 29.1393 where *I* is the minimum intensity prescribed in § 29.1391 for the corresponding angles in the horizontal plane.

(3) *Intensities in overlaps between adjacent signals.* No intensity in any overlap between adjacent signals may exceed the values in § 29.1395, except that higher intensities in overlaps may be used with the use of main beam intensities substantially greater than the minima specified in §§ 29.1391 and 29.1393 if the overlap intensities in relation to the main beam intensities do not adversely affect signal clarity.

### § 29.1391 Minimum intensities in the horizontal plane of forward and rear position lights.

Each position light intensity must equal or exceed the applicable values in the following table:

| *Dihedral angle (light included)* | *Angle from right or left or longitudinal axis, measured from dead ahead* | *Intensity (candles)* |
|---|---|---|
| *L* and *R* (forward red and green). | 0° to 10° | 40 |
| | 10° to 20° | 30 |
| | 20° to 110° | 5 |
| *A* (rear white) | 110° to 180° | 20 |

### § 29.1393 Minimum intensities in any vertical plane of forward and rear position lights.

Each position light intensity must equal or exceed the applicable values in the following table:

| *Angle above or below the horizontal plane:* | *Intensity* |
|---|---|
| 0° | 1.00*I* |
| 0° to 5° | 0.90*I* |
| 5° to 10° | 0.80*I* |
| 10° to 15° | 0.70*I* |
| 15° to 20° | 0.50*I* |
| 20° to 30° | 0.30*I* |
| 30° to 40° | 0.10*I* |
| 40° to 90° | 0.05*I* |

### § 29.1395 Maximum intensities in overlapping beams of forward and rear position lights.

No position light intensity may exceed the applicable values in the following table, except as provided in § 29.1389(b)(3).

| *Overlaps* | *Maximum intensity* | |
|---|---|---|
| | *Area A* | *Area B* |
| Green in dihedral angle *L* | 10 | 1 |
| Red in dihedral angle *R* | 10 | 1 |
| Green in dihedral angle *A* | 5 | 1 |
| Red in dihedral angle *A* | 5 | 1 |
| Rear white in dihedral angle *L* | 5 | 1 |
| Rear white in dihedral angle *R* | 5 | 1 |

Where—

(a) Area A includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 10° but less than 20°; and

(b) Area B includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 20°.

### § 29.1397 Color specifications.

Each position light color must have the applicable International Commission on Illumination chromaticity coordinates as follows:

(a) *Aviation red*—

''$y$'' is not greater than 0.335; and

''$z$'' is not greater than 0.002.

(b) *Aviation green*—

''$x$'' is not greater than $0.440-0.320y$;

''$x$'' is not greater than $y-0.170$; and

''$y$'' is not less than $0.390-0.170x$.

(c) *Aviation white*—

''$x$'' is not less than 0.300 and not greater than 0.540;

''$y$'' is not less than ''$x-0.040$'' or ''$y_c-0.010$,'' whichever is the smaller; and

''$y$'' is not greater than ''$x+0.020$'' nor ''$0.636-0.400x$'';

Where ''$y_0$'' is the ''$y$'' coordinate of the Planckian radiator for the value of ''$x$'' considered.

[(Amdt. 29–7, Eff. 8/11/71)]

### § 29.1399 Riding light.

(a) Each riding light required for water operation must be installed so that it can—

(1) Show a white light for at least two miles at night under clear atmospheric conditions; and

(2) Show a maximum practicable unbroken light with the rotorcraft on the water.

(b) Externally hung lights may be used.

### § 29.1401 Anticollision light system.

(a) *General.* If certification for night operation is requested, the rotorcraft must have an anticollision light system that—

(1) Consists of one or more approved anticollision lights located so that their emitted light will not impair the crew's vision or detract from the conspicuity of the position lights; and

(2) Meets the requirements of paragraphs (b) through (f) of this section.

(b) *Field of coverage.* The system must consist of enough lights to illuminate the vital areas around the rotorcraft, considering the physical configuration and flight characteristics of the rotorcraft. The field of coverage must extend in each direction within at least 30° above and 30° below the horizontal plane of the rotorcraft, except that there may be solid angles of obstructed visibility totaling not more than 0.5 steradians.

(c) *Flashing characteristics.* The arrangement of the system, that is, the number of light sources, beam width, speed of rotation, and other characteristics, must give an effective flash frequency of not less than 40, nor more than 100, cycles per minute. The effective flash frequency is the frequency at which the rotorcraft's complete anticollision light system is observed from a distance, and applies to each sector of light including any overlaps that exist when the system consists of more than one light source. In overlaps, flash frequencies may exceed 100, but not 180 cycles per minute.

(d) *Color.* Each anticollision light must be aviation red and must meet the applicable requirements of § 29.1397.

(e) *Light intensity.* The minimum light intensities in any vertical plane, measured with the red filter (if used) and expressed in terms of ''effective'' intensities, must meet the requirements of paragraph (f) of this section. The following relation must be assumed:

$$Ie = \frac{\int_{t_1}^{t_2} I(t)dt}{0.2 + (t_2 - t_1)}$$

Where—

$I_e$ = effective intensity (candles).

$I(t)$ = instantaneous intensity as a function of time.

$t_2 - t_1$ = flash time interval (seconds).

Normally, the maximum value of effective intensity is obtained when $t_2$ and $t_1$ are chosen so that the effective intensity is equal to the instantaneous intensity at $t_2$ and $t_1$.

(f) *Minimum effective intensities for anticollision light.* Each anticollision light effective intensity must equal or exceed the applicable values in the following table:

| *Angle above or below the horizontal plane:* | *Effective intensity (candles)* |
|---|---|
| 0° to 5° | 150 |
| 5° to 10° | 90 |
| 10° to 20° | 30 |
| 20° to 30° | 15 |

[(Amdt. 29–7, Eff. 8/11/71); (Amdt. 29–11, Eff. 2/5/76)]

## SAFETY EQUIPMENT

### § 29.1411 General.

(a) *Accessibility.* Required safety equipment to be used by the crew in an emergency, such as automatic liferaft releases, must be readily accessible.

(b) *Stowage provisions.* Stowage provisions for required emergency equipment must be furnished and must—

(1) Be arranged so that the equipment is directly accessible and its location is obvious; and

(2) Protect the safety equipment from inadvertent damage.

(c) *Emergency exit descent device.* The stowage provisions for the emergency exit descent device required by § 29.809(f) must be at the exits for which they are intended.

(d) *Liferafts.* Liferafts must be stowed near exits through which the rafts can be launched during an unplanned ditching. Rafts automatically or remotely released outside the rotorcraft must be attached to the rotorcraft by the static line prescribed in § 29.1415.

(e) *Long-range signaling device.* The stowage provisions for the long-range signaling device required by § 29.1415 must be near an exit available during an unplanned ditching.

(f) *Life preservers.* Each life preserver must be within easy reach of each occupant while seated.

### § 29.1413 Safety belts: Passenger warning device.

(a) If there are means to indicate to the passengers when safety belts should be fastened, they must be installed to be operated from either pilot seat.

(b) Each safety belt must be equipped with a metal to metal latching device.

[(Amdt. 29–16, Eff. 12/4/78)]

### § 29.1415 Ditching equipment.

(a) Emergency flotation and signaling equipment required by any operating rule of this chapter must meet the requirements of this section.

(b) Each liferaft and each life preserver must be approved. In addition—

(1) Provide not less than two rafts, of an approximately equal rated capacity and buoyancy to accommodate the occupants of the rotorcraft; and

(2) Each raft must have a trailing line, and must have a static line designed to hold the raft near the rotorcraft but to release it if the rotorcraft becomes totally submerged.

(c) Approved survival equipment must be attached to each liferaft.

(d) [There must be an approved survival type emergency locator transmitter for use in one life raft.]

(Amdt. 29–8, Eff. 10/21/71); (Amdt. 29–19, Eff. 9/9/80); (Amdt. 29–30, Eff. 4/5/90); [(Amdt. 29–33, Eff. 6/21/94)]

### § 29.1419 Ice protection.

(a) To obtain certification for flight into icing conditions, compliance with this section must be shown.

(b) It must be demonstrated that the rotorcraft can be safely operated in the continuous maximum and intermittent maximum icing conditions determined under appendix C of this part within the rotorcraft altitude envelope. An analysis must be performed to establish, on the basis of the rotorcraft's operational needs, the adequacy of the ice protection system for the various components of the rotorcraft.

(c) In addition to the analysis and physical evaluation prescribed in paragraph (b) of this section, the effectiveness of the ice protection system and its components must be shown by flight tests of the rotorcraft or its components in measured natural atmospheric icing conditions and by one or more of the following tests as found necessary to determine the adequacy of the ice protection system:

(1) Laboratory dry air or simulated icing tests, or a combination of both, of the components or models of the components.

(2) Flight dry air tests of the ice protection system as a whole, or its individual components.

(3) Flight tests of the rotorcraft or its components in measured simulated icing conditions.

(d) The ice protection provisions of this section are considered to be applicable primarily to the airframe. Powerplant installation requirements are contained in subpart E of this part.

(e) A means must be identified or provided for determining the formation of ice on critical parts of the rotorcraft. Unless otherwise restricted, the means must be available for nighttime as well as daytime operation. The rotorcraft flight manual must describe the means of determining ice formation and must contain information necessary for safe operation of the rotorcraft in icing conditions.

[(Amdt. 29–21, Eff. 3/2/83)]

## MISCELLANEOUS EQUIPMENT

### § 29.1431 Electronic equipment.

(a) Radio communication and navigation installations must be free from hazards in themselves, in their method of operation, and in their effects on other components, under any critical environmental conditions.

(b) Radio communication and navigation equipment, controls, and wiring must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other radio or electronic unit, or system of units, required by this chapter.

### § 29.1433 Vacuum systems.

(a) There must be means, in addition to the normal pressure relief, to automatically relieve the pressure in the discharge lines from the vacuum air pump when the delivery temperature of the air becomes unsafe.

(b) Each vacuum air system line and fitting on the discharge side of the pump that might contain flammable vapors or fluids must meet the requirements of § 29.1183 if they are in a designated fire zone.

(c) Other vacuum air system components in designated fire zones must be at least fire resistant.

### § 29.1435 Hydraulic systems.

(a) *Design.* Each hydraulic system must be designed as follows:

(1) Each element of the hydraulic system must be designed to withstand, without detrimental, permanent deformation, any structural loads that may be imposed simultaneously with the maximum operating hydraulic loads.

(2) Each element of the hydraulic system must be designed to withstand pressures sufficiently greater than those prescribed in paragraph (b) of this section to show that the system will not rupture under service conditions.

(3) There must be means to indicate the pressure in each main hydraulic power system.

(4) There must be means to ensure that no pressure in any part of the system will exceed a safe limit above the maximum operating pressure of the system, and to prevent excessive pressures resulting from any fluid volumetric change in lines likely to remain closed long enough for such a change to take place. The possibility of detrimental transient (surge) pressures during operation must be considered.

(5) Each hydraulic line, fitting, and component must be installed and supported to prevent excessive vibration and to withstand inertia loads. Each element of the installation must be protected from abrasion, corrosion, and mechanical damage.

(6) Means for providing flexibility must be used to connect points, in a hydraulic fluid line, between which relative motion or differential vibration exists.

(b) *Tests.* Each element of the system must be tested to a proof pressure of 1.5 times the maximum pressure to which that element will be subjected in normal operation, without failure, malfunction, or detrimental deformation, of any part of the system.

(c) *Fire protection.* Each hydraulic system using flammable hydraulic fluid must meet the applicable requirements of §§ 29.861, 29.1183, 29.1185, and 29.1189.

### § 29.1439 Protective breathing equipment.

(a) If one or more cargo or baggage compartments are to be accessible in flight, protective breathing equipment must be available for an appropriate crewmember.

(b) For protective breathing equipment required by paragraph (a) of this section or by any operating rule of this chapter—

(1) That equipment must be designed to protect the crew from smoke, carbon dioxide, and other harmful gases while on flight deck duty;

(2) That equipment must include—

(i) Masks covering the eyes, nose, and mouth; or

(ii) Masks covering the nose and mouth, plus accessory equipment to protect the eyes; and

(3) That equipment must supply protective oxygen of 10 minutes duration per crewmember at a pressure altitude of 8,000 feet with a respiratory minute volume of 30 liters per minute BTPD.

### § 29.1457 Cockpit voice recorders.

(a) Each cockpit voice recorder required by the operating rules of this chapter must be approved, and must be installed so that it will record the following:

(1) Voice communications transmitted from or received in the rotorcraft by radio.

(2) Voice communications of flight crewmembers on the flight deck.

(3) Voice communications of flight crewmembers on the flight deck, using the rotorcraft's interphone system.

(4) Voice or audio signals identifying navigation or approach aids introduced into a headset or speaker.

(5) Voice communications of flight crewmembers using the passenger loudspeaker system, if there is such a system, and if the fourth channel is available in accordance with the requirements of paragraph (c)(4)(ii) of this section.

(b) The recording requirements of paragraph (a)(2) of this section may be met—

(1) By installing a cockpit-mounted area microphone, located in the best position for recording voice communications originating at the first and second pilot stations and voice communications of other crewmembers on the flight deck when directed to those stations; or

(2) By installing a continually energized or voice-actuated lip microphone at the first and second pilot stations.

The microphone specified in this paragraph must be so located and, if necessary, the preamplifiers and filters of the recorder must be so adjusted or supplemented, that the recorded communications are intelligible when recorded under flight cockpit noise conditions and played back. The level of intelligibility must be approved by the Administrator. Repeated aural or visual playback of the record may be used in evaluating intelligibility.

(c) Each cockpit voice recorder must be installed so that the part of the communication or audio signals specified in paragraph (a) of this section obtained from each of the following sources is recorded on a separate channel:

(1) For the first channel, from each microphone, headset, or speaker used at the first pilot station.

(2) For the second channel, from each microphone, headset, or speaker used at the second pilot station.

(3) For the third channel, from the cockpit-mounted area microphone, or the continually energized or voice-actuated lip microphones at the first and second pilot stations.

(4) For the fourth channel, from—

(i) Each microphone, headset, or speaker used at the stations for the third and fourth crewmembers; or

(ii) If the stations specified in paragraph (c)(4)(i) of this section are not required or if the signal at such a station is picked up by another channel, each microphone on the flight deck that is used with the passenger loudspeaker system if its signals are not picked up by another channel.

(iii) Each microphone on the flight deck that is used with the rotorcraft's loudspeaker system if its signals are not picked up by another channel.

(d) Each cockpit voice recorder must be installed so that—

(1) It receives its electric power from the bus that provides the maximum reliability for operation of the cockpit voice recorder without jeopardizing service to essential or emergency loads;

(2) There is an automatic means to simultaneously stop the recorder and prevent each erasure feature from functioning, within 10 minutes after crash impact; and

(3) There is an aural or visual means for preflight checking of the recorder for proper operation.

(e) The record container must be located and mounted to minimize the probability of rupture of the container as a result of crash impact and consequent heat damage to the record from fire.

(f) If the cockpit voice recorder has a bulk erasure device, the installation must be designed to minimize the probability of inadvertent operation and actuation of the device during crash impact.

(g) Each recorder container must be either bright orange or bright yellow.

[(Amdt. 29–6, Eff. 7/8/70)]

### § 29.1459 Flight recorder.

(a) Each flight recorder required by the operating rules of Subchapter G of this chapter must be installed so that—

(1) It is supplied with airspeed, altitude, and directional data obtained from sources that meet the accuracy requirement of §§ 29.1323, 29.1325, and 29.1327 of this part, as applicable;

(2) The vertical acceleration sensor is rigidly attached, and located longitudinally within the approved center gravity limits of the rotorcraft;

(3) It receives its electrical power from the bus that provides the maximum reliability for operation of the flight recorder without jeopardizing service to essential or emergency loads;

(4) There is an aural or visual means for preflight checking of the recorder for proper recording of data in the storage medium; and

(5) Except for recorders powered solely by the engine-driven electrical generator system, there is an automatic means to simultaneously stop a recorder that has a data erasure feature and prevent each erasure feature from functioning, within 10 minutes after any crash impact.

(b) Each nonejectable recorder container must be located and mounted so as to minimize the probability of container rupture resulting from crash impact and subsequent damage to the record from fire.

(c) A correlation must be established between the flight recorder readings of airspeed, altitude, and heading and the corresponding readings (taking into account correction factors) of the first pilot's instruments. This correlation must cover the airspeed range over which the aircraft is to be operated, the range of altitude to which the aircraft is limited, and 360 degrees of heading. Correlation may be established on the ground as appropriate.

(d) Each recorder container must—

(1) Be either bright orange or bright yellow;

(2) Have a reflective tape affixed to its external surface to facilitate its location under water; and

(3) Have a underwater locating device, when required by the operating rules of this chapter, on or adjacent to the container which is secured in such a manner that it is not likely to be separated during crash impact.

[(Amdt. 29–25, Eff. 10/11/88)]

## § 29.1461 Equipment containing high energy rotors.

(a) Equipment containing high energy rotors must meet paragraph (b), (c), or (d) of this section.

(b) High energy rotors contained in equipment must be able to withstand damage caused by malfunctions, vibration, abnormal speeds, and abnormal temperatures. In addition—

(1) Auxiliary rotor cases must be able to contain damage caused by the failure of high energy rotor blades; and

(2) Equipment control devices, systems, and instrumentation must reasonably ensure that no operating limitations affecting the integrity of high energy rotors will be exceeded in service.

(c) It must be shown by test that equipment containing high energy rotors can contain any failure of a high energy rotor that occurs at the highest speed obtainable with the normal speed control devices inoperative.

(d) Equipment containing high energy rotors must be located where rotor failure will neither endanger the occupants nor adversely affect continued safe flight.

[(Amdt. 29–3, Eff. 2/25/68)]

# Subpart G—Operating Limitations and Information

### § 29.1501 General.

(a) Each operating limitation specified in §§ 29.1503 through 29.1525 and other limitations and information necessary for safe operation must be established.

(b) The operating limitations and other information necessary for safe operation must be made available to the crewmembers as prescribed in §§ 29.1541 through 29.1589.

[(Amdt. 29–15, Eff. 3/1/78)]

## OPERATING LIMITATIONS

### § 29.1503 Airspeed limitations: General.

(a) An operating speed range must be established.

(b) When airspeed limitations are a function of weight, weight distribution, altitude, rotor speed, power, or other factors, airspeed limitations corresponding with the critical combinations of these factors must be established.

### § 29.1505 Never-exceed speed.

(a) The never-exceed speed, $V_{NE}$, must be established so that it is—

(1) Not less than 40 knots (CAS); and

(2) Not more than the lesser of—

(i) 0.9 times the maximum forward speeds established under § 29.309;

(ii) 0.9 times the maximum speed shown under §§ 29.251 and 29.629; or

(iii) 0.9 times the maximum speed substantiated for advancing blade tip mach number effects under critical altitude conditions.

(b) $V_{NE}$ may vary with altitude, r.p.m., temperature, and weight, if—

(1) No more than two of these variables (or no more than two instruments integrating more than one of these variables) are used at one time; and

(2) The ranges of these variables (or of the indications on instruments integrating more than one of these variables) are large enough to allow an operationally practical and safe variation of $V_{NE}$.

(c) For helicopters, a stabilized power-off $V_{NE}$ denoted as $V_{NE}$ (power-off) may be established at a speed less than $V_{NE}$ established pursuant to paragraph (a) of this section, if the following conditions are met:

(1) $V_{NE}$ (power-off) is not less than a speed midway between the power-on $V_{NE}$ and the speed used in meeting the requirements of—

(i) § 29.67(a)(3) for Category A helicopters;

(ii) § 29.65(a) for Category B helicopters, except multi-engine helicopters meeting the requirements of § 29.67(b); and

(iii) § 29.67(b) for multi-engine Category B helicopters meeting the requirements of § 29.67(b).

(2) $V_{NE}$ (power-off) is—

(i) A constant airspeed;

(ii) A constant amount less than power-on $V_{NE}$; or

(iii) A constant airspeed for a portion of the altitude range for which certification is requested, and a constant amount less than power-on $V_{NE}$ for the remainder of the altitude range.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1509 Rotor speed.

(a) *Maximum power-off (autorotation).* The maximum power-off rotor speed must be established so that it does not exceed 95 percent of the lesser of—

(1) The maximum design r.p.m. determined under § 29.309(b); and

(2) The maximum r.p.m. shown during the type tests.

(b) *Minimum power-off.* The minimum power-off rotor speed must be established so that it is not less than 105 percent of the greater of—

(1) The minimum shown during the type tests; and

(2) The minimum determined by design substantiation.

(c) *Minimum power-on.* The minimum power-on rotor speed must be established so that it is—

(1) Not less than the greater of—

(i) The minimum shown during the type tests; and

(ii) The minimum determined by design substantiation; and

(2) Not more than a value determined under § 29.33(a)(1) and (c)(1).

### § 29.1517 Limiting height-speed envelope.

For Category A rotorcraft, if a range of heights exists at any speed, including zero, within which it is not possible to make a safe landing following power failure, the range of heights and its variation with forward speed must be established, together with any other pertinent information, such as the kind of landing surface.

【(Amdt. 29–21, Eff. 3/2/83)】

### § 29.1519 Weight and center of gravity.

The weight and center of gravity limitations determined under §§ 29.25 and 29.27, respectively, must be established as operating limitations.

### § 29.1521 Powerplant limitations.

(a) *General.* The powerplant limitations prescribed in this section must be established so that they do not exceed the corresponding limits for which the engines are type certificated.

(b) *Takeoff operation.* The powerplant takeoff operation must be limited by—

(1) The maximum rotational speed which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable manifold pressure (for reciprocating engines);

(3) The maximum allowable turbine inlet or turbine outlet gas temperature (for turbine engines);

(4) The maximum allowable power or torque for each engine, considering the power input limitations of the transmission with all engines operating;

(5) The maximum allowable power or torque for each engine considering the power input limitations of the transmission with one engine inoperative;

(6) The time limit for the use of the power corresponding to the limitations established in paragraphs (b)(1) through (5) of this section; and

(7) If the time limit established in paragraph (b)(6) of this paragraph exceeds 2 minutes—

(i) The maximum allowable cylinder head or coolant outlet temperature (for reciprocating engines); and

(ii) The maximum allowable engine and transmission oil temperatures.

(c) *Continuous operation.* The continuous operation must be limited by—

(1) The maximum rotational speed, which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The minimum rotational speed shown under the rotor speed requirements in § 29.1509(c).

(3) The maximum allowable manifold pressure (for reciprocating engines);

(4) The maximum allowable turbine inlet or turbine outlet gas temperature (for turbine engines);

(5) The maximum allowable power or torque for each engine, considering the power input limitations of the transmission with all engines operating;

(6) The maximum allowable power or torque for each engine, considering the power input limitations of the transmission with one engine inoperative; and

(7) The maximum allowable temperatures for—

(i) The cylinder head or coolant outlet (for reciprocating engines);

(ii) The engine oil; and

(iii) The transmission oil.

(d) *Fuel grade or designation.* The minimum fuel grade (for reciprocating engines) or fuel designation (for turbine engines) must be established so that it is not less than that required for the operation of the engines within the limitations in paragraphs (b) and (c) of this section.

(e) *Ambient temperature.* Ambient temperature limitations (including limitations for winterization installations if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions of §§ 29.1041 through 29.1049 is shown.

(f) *Two and one-half-minute OEI power operation.* Unless otherwise authorized, the use of 2½-minute OEI power must be limited to engine failure operation of multiengine, turbine-powered rotorcraft for not longer than 2½ minutes for any period in which that power is used. The use of 2½-minute OEI power must also be limited by—

(1) The maximum rotational speed, which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable gas temperature;

(3) The maximum allowable torque; and

(4) The maximum allowable oil temperature.

(g) *Thirty-minute OEI power operation.* Unless otherwise authorized, the use of 30-minute OEI power must be limited to multiengine, turbine-powered rotorcraft for not longer than 30 minutes after failure of an engine. The use of 30-minute OEI power must also be limited by—

(1) The maximum rotational speed which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable gas temperature;

(3) The maximum allowable torque; and

(4) The maximum allowable oil temperature.

(h) *Continuous OEI power operation.* Unless otherwise authorized, the use of continuous OEI power must be limited to multiengine, turbine-powered rotorcraft for continued flight after failure of an engine. The use of continuous OEI power must also be limited by—

(1) The maximum rotational speed, which may not be greater than—

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests.

(2) The maximum allowable gas temperature;

(3) The maximum allowable torque; and

(4) The maximum allowable oil temperature.

[(i) *Rated 30-second OEI power operation.* Rated 30-second OEI power is permitted only on multiengine, turbine-powered rotorcraft, also certificated for the use of rated 2-minute OEI power, and can only be used for continued operation of the remaining engine(s) after a failure or precautionary shutdown of an engine. It must be shown that following application of 30-second OEI power, any damage will be readily detectable by the applicable inspections and other related procedures furnished in accordance with section A29.4 of appendix A of this part and section A33.4 of appendix A of part 33. The use of 30-second OEI power must be limited to not more than 30 seconds for any period in which that power is used, and by—

[(1) The maximum rotational speed, which may not be greater than—

[(i) The maximum value determined by the rotor design; or

[(ii) The maximum value demonstrated during the type tests;

[(2) The maximum allowable gas temperature; and

[(3) The maximum allowable torque.

[(j) *Rated 2-minute OEI power operation.* Rated 2-minute OEI power is permitted only on multiengine, turbine-powered rotorcraft, also certificated for the use of rated 30-second OEI power, and can only be used for continued operation of the remaining engine(s) after a failure or precautionary shutdown of an engine. It must be shown that following application of 2-minute OEI power, any damage will be readily detectable by the applicable inspections and other related procedures furnished in accordance with section A29.4 of appendix A of this part and section A33.4 of appendix A of part 33. The use of 2-minute OEI power must be limited to not more than 2 minutes for any period in which that power is used, and by—

[(1) The maximum rotational speed, which may not be greater than—

[(i) The maximum value determined by the rotor design; or

[(ii) The maximum value demonstrated during the type tests;

[(2) The maximum allowable gas temperature; and

[(3) The maximum allowable torque.]

(Amdt. 29–1, Eff. 8/12/65); (Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–34, Eff. 10/17/94)]

### § 29.1522 Auxiliary power unit limitations.

If an auxiliary power unit that meets the requirements of TSO–C77 is installed in the rotorcraft, the limitations established for that auxiliary power unit under the TSO including the categories of operation must be specified as operating limitations for the rotorcraft.

[(Amdt. 29–17, Eff. 12/1/78)]

### § 29.1523 Minimum flight crew.

The minimum flight crew must be established so that it is sufficient for safe operation, considering—

(a) The workload on individual crewmembers;

(b) The accessibility and ease of operation of necessary controls by the appropriate crewmember; and

(c) The kinds of operation authorized under § 29.1525.

### § 29.1525 Kinds of operations.

The kinds of operations (such as VFR, IFR, day, night, or icing) for which the rotorcraft is approved are established by demonstrated compliance with the applicable certification requirements and by the installed equipment.

[(Amdt. 29–24, Eff. 12/6/84)]

### § 29.1527 Maximum operating altitude.

The maximum altitude up to which operation is allowed, as limited by flight, structural, powerplant, functional, or equipment characteristics, must be established.

[(Amdt. 29–15, Eff. 3/1/78)]

### § 29.1529 Instructions for Continued Airworthiness.

The applicant must prepare Instructions for Continued Airworthiness in accordance with appendix A to this part that are acceptable to the Administrator. The instructions may be incomplete at type certification if a program exists to ensure their completion prior to delivery of the first rotorcraft or issuance of a standard certificate of airworthiness, whichever occurs later.

[(Amdt. 29–4, Eff. 10/17/68); (Amdt. 29–20, Eff. 10/14/80)]

## MARKINGS AND PLACARDS

### § 29.1541 General.

(a) The rotorcraft must contain—

(1) The markings and placards specified in §§ 29.1545 through 29.1565; and

(2) Any additional information, instrument markings, and placards required for the safe operation of the rotorcraft if it has unusual design, operating or handling characteristics.

(b) Each marking and placard prescribed in paragraph (a) of this section—

(1) Must be displayed in a conspicuous place; and

(2) May not be easily erased, disfigured, or obscured.

### § 29.1543 Instrument markings: General.

For each instrument—

(a) When markings are on the cover glass of the instrument there must be means to maintain the correct alignment of the glass cover with the face of the dial; and

(b) Each arc and line must be wide enough and located to be clearly visible to the pilot.

### § 29.1545 Airspeed indicator.

(a) Each airspeed indicator must be marked as specified in paragraph (b) of this section, with the marks located at the corresponding indicated airspeeds.

(b) The following markings must be made:

(1) A red radial line—

(i) For rotorcraft other than helicopters, at $V_{NE}$; and

(ii) For helicopters, at $V_{NE}$ (power-on).

(2) A red, cross-hatched radial line at $V_{NE}$ (power-off) for helicopters, if $V_{NE}$ (power-off) is less than $V_{NE}$ (power-on).

(3) For the caution range, a yellow arc.

(4) For the safe operating range, a green arc.

[(Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–17, Eff. 12/1/78)]

### § 29.1547 Magnetic direction indicator.

(a) A placard meeting the requirements of this section must be installed on or near the magnetic direction indicator.

(b) The placard must show the calibration of the instrument in level flight with the engines operating.

(c) The placard must state whether the calibration was made with radio receivers on or off.

(d) Each calibration reading must be in terms of magnetic heading in not more than 45° increments.

### § 29.1549 Powerplant instruments.

For each required powerplant instrument, as appropriate to the type of instruments—

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

(c) Each takeoff and precautionary range must be marked with a yellow arc or yellow line;

(d) Each engine or propeller range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines; and

(e) [Each OEI limit or approved operating range must be marked to be clearly differentiated from the markings of paragraphs (a) through (d) of this section except that no marking is normally required for the 30-second OEI limit.]

(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88); [(Amdt. 29–34, Eff. 10/17/94)]

### § 29.1551 Oil quantity indicator.

Each oil quantity indicator must be marked with enough increments to indicate readily and accurately the quantity of oil.

### § 29.1553 Fuel quantity indicator.

If the unusable fuel supply for any tank exceeds one gallon, or five percent of the tank capacity, whichever is greater, a red arc must be marked on its indicator extending from the calibrated zero reading to the lowest reading obtainable in level flight.

### § 29.1555 Control markings.

(a) Each cockpit control, other than primary flight controls or control whose function is obvious, must be plainly marked as to its function and method of operation.

(b) For powerplant fuel controls—

(1) Each fuel tank selector valve control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;

(2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on, or adjacent to, the selector for those tanks; and

(3) Each valve control for any engine of a multiengine rotorcraft must be marked to indicate the position corresponding to each engine controlled.

(c) Usable fuel capacity must be marked as follows:

(1) For fuel systems having no selector controls, the usable fuel capacity of the system must be indicated at the fuel quantity indicator.

(2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control.

(d) For accessory, auxiliary, and emergency controls—

(1) Each essential visual position indicator, such as those showing rotor pitch or landing gear position, must be marked so that each crewmember can determine at any time the position of the unit to which it relates; and

(2) Each emergency control must be red and must be marked as to method of operation.

(e) For rotorcraft incorporating retractable landing gear, the maximum landing gear operating speed must be displayed in clear view of the pilot.

[(Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1557 Miscellaneous markings and placards.

(a) *Baggage and cargo compartments, and ballast location.* Each baggage and cargo compartment, and each ballast location must have a placard stating any limitations on contents, including weight, that are necessary under the loading requirements.

(b) *Seats.* If the maximum allowable weight to be carried in a seat is less than 170 pounds, a placard stating the lesser weight must be permanently attached to the seat structure.

(c) *Fuel and oil filler openings.* The following apply:

(1) Fuel filler openings must be marked at or near the filler cover with—

(i) The word "fuel";

(ii) For reciprocating engine powered rotorcraft, the minimum fuel grade;

(iii) For turbine-engine-powered rotorcraft, the permissible fuel designations, except that if impractical, this information may be included in the rotorcraft flight manual, and the fuel filler may be marked with an appropriate reference to the flight manual; and

(iv) For pressure fueling systems, the maximum permissible fueling supply pressure and the maximum permissible defueling pressure.

(2) Oil filler openings must be marked at or near the filler cover with the word "oil".

(d) *Emergency exit placards.* Each placard and operating control for each emergency exit must differ in color from the surrounding fuselage surface as prescribed in § 29.811(h)(2). A placard must be near each emergency exit control and must clearly indicate the location of that exit and its method of operation.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–12, Eff. 2/1/77); (Amdt. 29–26, Eff. 10/3/88)]

### § 29.1559 Limitations placard.

There must be a placard in clear view of the pilot that specifies the kinds of operations (VFR, IFR, day, night, or icing) for which the rotorcraft is approved.

[(Amdt. 29–4, Eff. 10/17/68); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1561 Safety equipment.

(a) Each safety equipment control to be operated by the crew in emergency, such as controls for automatic liferaft releases, must be plainly marked as to its method of operation.

(b) Each location, such as a locker or compartment, that carries any fire extinguishing, signaling, or other life saving equipment, must be so marked.

(c) Stowage provisions for required emergency equipment must be conspicuously marked to identify the contents and facilitate removal of the equipment.

(d) Each liferaft must have obviously marked operating instructions.

(e) Approved survival equipment must be marked for identification and method of operation.

### § 29.1565 Tail rotor.

Each tail rotor must be marked so that its disc is conspicuous under normal daylight ground conditions.

## ROTORCRAFT FLIGHT MANUAL

### § 29.1581 General.

(a) *Furnishing information.* A Rotorcraft Flight Manual must be furnished with each rotorcraft, and it must contain the following:

(1) Information required by §§ 29.1583 through 29.1589.

(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) *Approved information.* Each part of the manual listed in §§ 29.1583 through 29.1589 that is appropriate to the rotorcraft, must be furnished, verified, and approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual.

(c) [Reserved]

(d) *Table of contents.* Each Rotorcraft Flight Manual must include a table of contents if the complexity of the manual indicates a need for it.

[(Amdt. 29–15, Eff. 3/1/78)]

### § 29.1583 Operating limitations.

(a) *Airspeed and rotor limitations.* Information necessary for the marking of airspeed and rotor limitations on or near their respective indicators must be furnished. The significance of each limitation and of the color coding must be explained.

(b) *Powerplant limitations.* The following information must be furnished:

(1) Limitations required by § 29.1521.

(2) Explanation of the limitations, when appropriate.

(3) Information necessary for marking the instruments required by §§ 29.1549 through 29.1553.

(c) *Weight and loading distribution.* The weight and center of gravity limits required by §§ 29.25 and 29.27, respectively, must be furnished. If the variety of possible loading conditions warrants, instructions must be included to allow ready observance of the limitations.

(d) *Flight crews.* When a flight crew of more than one is required, the number and functions of the minimum flight crew determined under § 29.1523 must be furnished.

(e) *Kinds of operation.* Each kind of operation for which the rotorcraft and its equipment installations are approved must be listed.

(f) *Limiting heights.* Enough information must be furnished to allow compliance with § 29.1517.

(g) *Maximum allowable wind.* For Category A rotorcraft, the maximum allowable wind for safe operation near the ground must be furnished.

(h) *Altitude.* The altitude established under § 29.1527 and an explanation of the limiting factors must be furnished.

(i) *Ambient temperature.* Maximum and minimum ambient temperature limitations must be furnished.

[(Amdt. 29–3, Eff. 2/25/68); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1585 Operating procedures.

(a) The parts of the manual containing operating procedures must have information concerning any normal and emergency procedures, and other information necessary for safe operation, including the applicable procedures, such as those involving minimum speeds, to be followed if an engine fails.

(b) For multiengine rotorcraft, information identifying each operating condition in which the fuel system independence prescribed in § 29.953 is necessary for safety must be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section.

(c) For helicopters for which a $V_{NE}$ (power-off) is established under § 29.1505(c), information must be furnished to explain the $V_{NE}$ (power-off) and the procedures for reducing airspeed to not more than the $V_{NE}$ (power-off) following failure of all engines.

(d) For each rotorcraft showing compliance with § 29.1353(c)(6)(ii) or (c)(6)(iii), the operating procedures for disconnecting the battery from its charging source must be furnished.

(e) If the unusable fuel supply in any tank exceeds 5 percent of the tank capacity, or 1 gallon, whichever is greater, information must be furnished which indicates that when the fuel quantity indicator reads "zero" in level flight, any fuel remaining in the fuel tank cannot be used safely in flight.

(f) Information on the total quantity of usable fuel for each fuel tank must be furnished.

(g) For Category B rotorcraft, the airspeeds and corresponding rotor speeds for minimum rate of descent and best glide angle as prescribed in § 29.71 must be provided.

[(Amdt. 29–2, Eff. 6/4/67); (Amdt. 29–15, Eff. 3/1/78); (Amdt. 29–17, Eff. 12/1/78); (Amdt. 29–24, Eff. 12/6/84)]

### § 29.1587 Performance information.

Flight manual performance information which exceeds any operating limitation may be shown only to the extent necessary for presentation clarity or to determine the effects of approved optional equipment or procedures. When data beyond operating limits are shown, the limits must be clearly indicated. The following must be provided:

(a) *Category A.* For each category A rotorcraft, the Rotorcraft Flight Manual must contain a summary of the performance data, including data necessary for the application of any operating rule of this chapter, together with descriptions of the conditions, such as airspeeds, under which this data was determined, and must contain—

(1) The indicated airspeeds corresponding with those determined for takeoff, and the procedures to be followed if the critical engine fails during takeoff;

(2) The airspeed calibrations;

(3) The techniques, associated airspeeds, and rates of descent for autorotative landings;

(4) [The rejected takeoff distance determined under § 29.62 and the takeoff distance determined under § 29.61 or § 29.63;

(5) [The landing data determined under § 29.81 or § 29.83; and

[(6) Out-of-ground effect hover performance determined under § 29.49 and the maximum safe wind demonstrated under the ambient conditions for data presented.]

***(5) [The landing data determined under § 29.81 or § 29.83;***

***[(6) The steady gradient of climb for each weight, altitude, and temperature for which takeoff data are to be scheduled, along the takeoff path determined in the flight conditions required in § 29.67(a)(1) and (a)(2):***

***(i) In the flight conditions required in § 29.67(a)(1) between the end of the takeoff distance and the point at which the rotorcraft is 200 feet above the takeoff surface (or 200 feet above the lowest point of the takeoff profile for elevated heliports);***

***(ii) In the flight conditions required in § 29.67(a)(2) between the points at which the rotorcraft is 200 and 1000 feet above the takeoff surface (or 200 and 1000 feet above the lowest point of the takeoff profile for elevated heliports); and***

***([7]) Out-of-ground effect hover performance determined under § 29.49 and the maximum safe wind demonstrated under the ambient conditions for data presented.]****

(b) *Category B.* For each category B rotorcraft, the Rotorcraft Flight Manual must contain—

(1) The takeoff distance and the climbout speed together with the pertinent information defining the flight path with respect to autorotative landing if an engine fails, including the calculated effects of altitude and temperature;

(2) The steady rates of climb and hovering ceiling, together with the corresponding airspeeds and other pertinent information, including the calculated effects of altitude and temperature;

(3) [The landing distance, appropriate airspeed, and type of landing surface, together with all pertinent information that might affect this distance, including the effects of weight, altitude, and temperature;]

(4) The maximum safe wind for operation near the ground;

(5) The airspeed calibrations;

(6) The height-speed envelope except for rotorcraft incorporating this as an operating limitation;

(7) Glide distance as a function of altitude when autorotating at the speeds and conditions for minimum rate of descent and best glide angle, as determined in § 29.71;

(8) [Out-of-ground effect hover performance determined under § 29.49 and the maximum safe wind demonstrated under the ambient conditions for data presented; and]

(9) Any additional performance data necessary for the application of any operating rule in this chapter.

(Amdt. 29–21, Eff. 3/2/83); (Amdt. 29–24, Eff. 12/6/84); [(Amdt. 29–39, Eff. 6/10/96)]; [***(Amdt. 29–40, Eff. 8/8/96)**]

### § 29.1589 Loading information.

There must be loading instructions for each possible loading condition between the maximum and minimum weights determined under § 29.25 that can result in a center of gravity beyond any extreme prescribed in § 29.27, assuming any probable occupant weights.

# Appendix B—Airworthiness Criteria for Helicopter Instrument Flight

I. *General.* A transport category helicopter may not be type certificated for operation under the instrument flight rules (IFR) of this chapter unless it meets the design and installation requirements contained in this appendix.

II. *Definitions.* (a) $V_{YI}$ means instrument climb speed, utilized instead of $V_Y$ for compliance with the climb requirements for instrument flight.

(b) $V_{NEI}$ means instrument flight never exceed speed, utilized instead of $V_{NE}$ for compliance with maximum limit speed requirements for instrument flight.

(c) $V_{MINI}$ means instrument flight minimum speed, utilized in complying with minimum limit speed requirements for instrument flight.

III. *Trim.* It must be possible to trim the cyclic, collective, and directional control forces to zero at all approved IFR airspeeds, power settings, and configurations appropriate to the type.

IV. *Static longitudinal stability.* (a) *General.* The helicopter must possess positive static longitudinal control force stability at critical combinations of weight and center of gravity at the conditions specified in paragraphs IV (b) through (f) of this appendix. The stick force must vary with speed so that any substantial speed change results in a stick force clearly perceptible to the pilot. The airspeed must return to within 10 percent of the trim speed when the control force is slowly released for each trim condition specified in paragraphs IV(b) through (f) of this appendix.

(b) *Climb.* Stability must be shown in climb throughout the speed range 20 knots either side of trim with—

(1) The helicopter trimmed at $V_{YI}$;

(2) Landing gear retracted (if retractable); and

(3) Power required for limit climb rate (at least 1,000 fpm) at $V_{YI}$ or maximum continuous power, whichever is less.

(c) *Cruise.* Stability must be shown throughout the speed range from 0.7 to 1.1 $V_H$ or $V_{NEI}$, whichever is lower, not to exceed ±20 knots from trim with—

(1) The helicopter trimmed and power adjusted for level flight at 0.9 $V_H$ or 0.9 $V_{NEI}$, whichever is lower; and

(2) Landing gear retracted (if retractable).

(d) *Slow cruise.* Stability must be shown throughout the speed range from 0.9 $V_{MINI}$ to 1.3 $V_{MINI}$ or 20 knots above trim speed, whichever is greater, with—

(1) The helicopter trimmed and power adjusted for level flight at 1.1 $V_{MINI}$; and

(2) Landing gear retracted (if retractable).

(e) *Descent.* Stability must be shown throughout the speed range 20 knots either side of trim with—

(1) The helicopter trimmed at 0.8 $V_H$ or 0.8 $V_{NEI}$ (or 0.8 $V_{LE}$ for the landing gear extended case), whichever is lower;

(2) Power required for 1,000 fpm descent at trim speed; and

(3) Landing gear extended and retracted, if applicable.

(f) *Approach.* Stability must be shown throughout the speed range from 0.7 times the minimum recommended approach speed to 20 knots above the maximum recommended approach speed with—

(1) The helicopter trimmed at the recommended approach speed or speeds;

(2) Landing gear extended and retracted, if applicable; and

(3) Power required to maintain a 3° glide path and power required to maintain the steepest approach gradient for which approval is requested.

V. *Static lateral-directional stability.* (a) Static directional stability must be positive throughout the approved ranges of airspeed, power, and vertical speed. In straight, steady sideslips up to ±10° from trim, directional control position must increase in approximately constant proportion to angle of sideslip. At greater angles up to the maximum sideslip angle appropriate to the type, increased directional control position must produce increased angle of sideslip.

(b) During sideslips up to ±10° from trim throughout the approved ranges of airspeed, power, and vertical speed there must be no negative dihedral stability perceptible to the pilot through lateral control motion or force. Longitudinal cycle movement with sideslip must not be excessive.

VI. *Dynamic stability.* (a) Any oscillation having a period of less than 5 seconds must damp to ½ amplitude in not more than one cycle.

(b) Any oscillation having a period of 5 seconds or more but less than 10 seconds must damp to ½ amplitude in not more than two cycles.

(c) Any oscillation having a period of 10 seconds or more but less than 20 seconds must be damped.

(d) Any oscillation having a period of 20 seconds or more may not achieve double amplitude in less than 20 seconds.

(e) Any aperiodic response may not achieve double amplitude in less than 9 seconds.

VII. *Stability augmentation system (SAS).* (a) If a SAS is used, the reliability of the SAS must be related to the effects of its failure. The occurrence of any failure condition which would prevent continued safe flight and landing must be extremely improbable. For any failure condition of the SAS which is not shown to be extremely improbable—

(1) The helicopter must be safely controllable and capable of prolonged instrument flight without undue pilot effort. Additional unrelated probable failures affecting the control system must be considered; and

(2) The flight characteristics requirements in subpart B of part 29 must be met throughout a practical flight envelope.

(b) The SAS must be designed so that it cannot create a hazardous deviation in flight path or produce hazardous loads on the helicopter during normal operation or in the event of malfunction or failure, assuming corrective action begins within an appropriate period of time. Where multiple systems are installed, subsequent malfunction conditions must be considered in sequence unless their occurrence is shown to be improbable.

VIII. *Equipment, systems, and installation.* The basic equipment and installation must comply with subpart F of part 29 through Amendment 29–14, with the following exceptions and additions:

(a) *Flight and navigation instruments.* (1) A magnetic gyro-stabilized direction indicator instead of the gyroscopic direction indicator required by § 29.1303(h); and

(2) A standby attitude indicator which meets the requirements of §§ 29.1303(g) (1) through (7), instead of a rate-of-turn indicator required by § 29.1303(g). If standby batteries are provided, they may be charged from the aircraft electrical system if adequate isolation is incorporated. The system must be designed so that the standby batteries may not be used for engine starting.

(b) *Miscellaneous requirements.* (1) Instrument systems and other systems essential for IFR flight that could be adversely affected by icing must be provided with adequate ice protection whether or not the rotorcraft is certificated for operation in icing conditions.

(2) There must be means in the generating system to automatically de-energize and disconnect from the main bus any power source developing hazardous overvoltage.

(3) Each required flight instrument using a power supply (electric, vacuum, etc.) must have a visual means integral with the instrument to indicate the adequacy of the power being supplied.

(4) When multiple systems performing like functions are required, each system must be grouped, routed, and spaced so that physical separation between systems is provided to ensure that a single malfunction will not adversely affect more than one system.

(5) For systems that operate the required flight instruments at each pilot's station—

(i) Only the required flight instruments for the first pilot may be connected to that operating system;

(ii) Additional instruments, systems, or equipment may not be connected to an operating system for a second pilot unless provisions are made to ensure the continued normal functioning of the required instruments in the event of any malfunction of the additional instruments, systems, or equipment which is not shown to be extremely improbable;

(iii) The equipment, systems, and installations must be designed so that one display of the information essential to the safety of flight which is provided by the instruments will remain available to a pilot, without additional crewmember action, after any single failure or combination of failures that is not shown to be extremely improbable; and

(iv) For single-pilot configurations, instruments which require a static source must be provided with a means of selecting an alternate source and that source must be calibrated.

[(6) In determining compliance with the requirements of § 29.1351(d)(2), the supply of electrical power to all systems necessary for flight under IFR must be included in the evaluation.]

(c) *Thunderstorm lights.* In addition to the instrument lights required by § 29.1381(a), thunderstorm lights which provide high intensity white flood lighting to the basic flight instruments must be provided. The thunderstorm lights must be installed to meet the requirements of § 29.1381(b).

IX. *Rotorcraft Flight Manual.* A Rotorcraft Flight Manual or Rotorcraft Flight Manual IFR Supplement must be provided and must contain—

(a) *Limitations.* The approved IFR flight envelope, the IFR flightcrew composition, the revised kinds of operation, and the steepest IFR precision approach gradient for which the helicopter is approved;

(b) *Procedures.* Required information for proper operation of IFR systems and the recommended procedures in the event of stability augmentation or electrical system failures; and

(c) *Performance.* If $V_{YI}$ differs from $V_Y$, climb performance at $V_{YI}$ and with maximum continuous power throughout the ranges of weight, altitude, and temperature for which approval is requested.

(Amdt. 29–21, Eff. 3/2/83); (Amdt. 29–31, Eff. 10/22/90); [(Amdt. 29–40, Eff. 8/8/96)]

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